PROJECT CHINA STONE

Surface Water 13

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13 SURFACE WATER

13.1 INTRODUCTION

This section provides an assessment of the impacts of Project China Stone (the project) on surface water resources. It includes a description of the surface water setting, proposed mine water management strategies and mine water management system and an assessment of surface water impacts.

A detailed assessment of the proposed open cut mine drainage arrangement and associated surface water impacts is presented in the *Open Cut Mine Drainage Report* (Appendix J).

Modelling of the performance of the proposed mine water management system is described in detail in the *Water Management System Modelling Report* (Appendix K).

13.2 SURFACE WATER SETTING

13.2.1 Regional Catchment Setting

The project site is located within the Belyando Basin, a sub-basin of the Burdekin Basin (Figure 13-1). The Burdekin Basin has a total catchment area to the coastline of approximately 135,000 km^2. The Belyando Basin is in the upper catchment of the larger Burdekin Basin. The Belyando Basin, together with the Cape Campaspe, Upper Burdekin and Suttor Basins, form the catchment of the Burdekin Falls Dam (Figure 13-1). Burdekin Falls Dam is approximately 255 km downstream of the project site. It is the largest dam in Queensland and has a total catchment area of approximately 114,000 km^2 and a full storage capacity of 1,860 Giga Litres (GL). The dam is at the upstream end of a regulated water supply scheme involving a series of downstream weirs that are fed by controlled releases from the dam.

The dominant land use in the Belyando Basin is cattle grazing. Both the Belyando Basin and the wider catchment of the Burdekin Falls Dam are characterised by high soil erosion rates which result in naturally elevated suspended sediment loads in watercourses. The Burdekin Falls Dam acts to attenuate natural sediment loads prior to any discharge into the lower Burdekin Basin and the coastal marine waters of Upstart Bay (Figure 13-1).

13.2.2 Local Catchment Setting

The local catchment setting is shown in Figure 13-2. The majority of the project site is drained by the headwaters of Tomahawk Creek and North Creek. These creeks flow to the south-east to the Belyando River downstream of the project site. The Belyando River is an ephemeral, regionally significant watercourse that enters the Suttor River upstream of the Burdekin Falls Dam (Figure 13-1).

The catchment of Lake Buchanan extends from Darkies Range to the west of the site (Figure 13-2). Only a very minor portion of the project site is within the Lake Buchanan catchment. Minor areas in the south-west of the project site also drain to the Carmichael River catchment via minor drainage lines (Figure 13-2).

The site is located at the head of the Tomahawk and North Creek catchments and site drainage is therefore highly ephemeral. There are no major waterways traversing the project site. The Department of Natural Resources and Mines (DNRM) have conducted a watercourse determination, under the *Water Act 2000* (Water Act), which confirmed there are no watercourses within the project site.

The majority of the project site drains towards the east from Darkies Range at the western boundary of the site. Site drainage features include a network of gullies in the steeper topography associated with Darkies Range (Figure 13-3). These gullies are characterised by steep rocky sides confining narrow rocky channels. The site drainage features transition from the steep gullies in the western area to minor drainage lines on the flatter areas of the site to the east of Darkes Range. The minor drainage lines in the south-eastern area of the project site have wide shallow flow paths (Figure 13-3).

The characteristics of the waterways and other significant surface water features in the project area are described in the following sections.

Tomahawk Creek and Upper Tributaries

The north of the project site is drained by the headwaters of Tomahawk Creek, and its tributary Pigeonhole Creek (Figure 13-2).

Drainage from two gully sub-catchments coalesce to form Pigeonhole Creek 10 km downstream of the project site. Pigeonhole Creek flows south-east for approximately 12 km before dissipating into overland flowpaths that drain parallel to Tomahawk Creek as the topography flattens. Under the Strahler ordering system, Pigeonhole Creek is a fourth order drainage feature.

A further four unnamed gully sub-catchments drain from Darkies Range to the south-east. These gullies transition to overland flow paths that traverse the north-east of the project site and continue to drain south-east, parallel to Tomahawk Creek.

These overland flowpaths that drain the project site coalesce with the main Tomahawk Creek channel at least 25 km downstream of the project site. Tomahawk Creek then flows a further 20 km into the main channel of the Belyando River approximately 40 km east of the project site (Figure 13-2). Tomahawk Creek is a first to second order drainage feature.

North Creek and Upper Tributaries

The south of the project site is drained by the headwaters of North Creek and its tributary, Laguna Creek (Figure 13-2). These headwaters are characterised by overland flowpaths that coalesce and dissipate over the flat topography before forming the defined flow channel of the North Creek watercourse approximately 20 km downstream of the project site. The overland flowpaths and downstream channel of North Creek are significantly degraded by cattle grazing.

Eight Mile Creek is a tributary of North Creek. The northern end of the proposed Carmichael Coal Mine site is located within the Eight Mile Creek sub-catchment (Figure 13-2). Eight Mile Creek joins North Creek approximately 28 km downstream of the project site. The respective catchment areas of North Creek and Eight Mile Creek to their confluence are 275 km^2 and 280 km^2, respectively. North Creek flows a further 25 km downstream of the confluence and joins the Belyando River at its confluence with the Moray Anabranch, approximately 45 km south-east of the project site (Figure 13-2). North Creek enters the Belyando River approximately 32 km upstream of the Tomahawk Creek-Belyando River confluence.

Under the Strahler ordering system, North Creek is a second order drainage feature upstream of the Eight Mile Creek confluence and a third order stream downstream of the confluence.

Belyando River

The Belyando River is an ephemeral, regionally significant watercourse that enters the Suttor River upstream of the Burdekin Falls Dam (Figure 13-1). The Belyando River is a braided river system comprising several anabranches occupying a broad floodplain (Figure 13-2).

Carmichael River

The Carmichael River is located approximately 23 km south of the project site and flows generally eastward for over 40 km into the Belyando River, 28 km upstream of the North Creek-Belyando River confluence.

Three small areas in the west and south-west of the project site (totalling 530 ha) drain to the Carmichael River catchment via minor drainage lines (Figure 13-3). Disturbance within these areas from project mining activities will be limited to an area of 2 ha in the south-west of the project site.

Proposed release points for mine-affected water from the proposed Carmichael Coal Mine Project are located on the Carmichael River (Draft Environmental Authority EPLM01470513) (Figure 13-2). The proposed release points, RP1 and RP2, are located approximately 18 km and 25 km upstream of the confluence of the Carmichael River and the Belyando River, respectively.

Lake Buchanan

Lake Buchanan is a shallow semi-arid lake located approximately 17 km west of the project site (Figure 13-1). Lake Buchanan lies within a closed, internally draining sub-basin located in the Thomson Basin. The Thomson Basin is a sub-catchment of the Cooper Creek Basin.

Lake Buchanan is fed by numerous drainage lines, including Mogga Creek to the north and Whistling Duck Creek to the east (Figure 13-2). The lake contains shallow, brackish water that becomes increasingly saline during dry periods. Salt deposits are present around the lake periphery. Grazing is an ongoing land use within the lake catchment.

The catchment of Lake Buchanan is bounded to the east by Darkies Range (Figure 13-2). Only a very minor portion of the project site (comprising 1.7 ha) lies within the catchment of Lake Buchanan (Figure 13-3). This area will not be disturbed by mining activities.

Dams and Wetlands

Two artificial farm dams and two seasonal wetlands are present on the project site (Figure 10-2). These features are fed by rainfall runoff. The environmental values of these surface water features are assessed in Section 10 – Aquatic Ecology.

13.2.3 Downstream Water Use and Environmental Values

The *Environmental Protection (Water) Policy 2009* (EPP Water) seeks to protect water in Queensland rivers, streams, wetlands, lakes, aquifers, estuaries and coastal areas while allowing for development that is ecologically sustainable. The EPP Water provides for determination of the environmental values of waters to be protected in two ways:

- For drainage basins and catchments gazetted under Schedule 1 of the EPP Water, assessment of waters against specified basin-specific environmental values; or
- For other waters, site-specific assessment against a comprehensive range of potential environmental values relating to aquatic ecosystems and human water uses.

The project site does not lie within a basin currently gazetted under Schedule 1 of the EPP Water. This means that a plan outlining environmental values and water quality objectives specific to this catchment has not been developed.

Environmental values relevant to the project have instead been derived from local and downstream land use, known water uses and through reference to published information, including the *Burdekin Water Quality Improvement Plan* (Burdekin WQIP) (NQ Dry Tropics, 2009).

The land uses in catchment areas downstream of the project site are predominantly grazing on natural pastures. Riparian and aquatic habitat on the project site and in the downstream catchment is degraded due to the effects of clearing and cattle grazing and persistent water bodies are known to be turbid (NQ Dry Tropics, 2009). Aquatic ecology values are considered slightly to moderately disturbed under the EPP Water classification. Aquaculture, industrial and recreational uses are not known to occur within the local catchment setting.

The Burdekin Falls Dam, located approximately 255 km downstream of the project site, is a significant water supply for drinking water and irrigated agriculture. Drinking water supply taken from the Burdekin Falls Dam requires treatment to potable standards.

The Burdekin WQIP provides draft water quality objectives for protection of aquatic ecosystems in freshwater streams. These draft water quality objectives are consistent with the corresponding default guideline trigger values from the *National Water Quality Management Strategy Paper 4: Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (2000) (ANZECC guidelines) and the *Queensland Water Quality Guidelines*

(QWQG) (EHP, 2009). The Burdekin WQIP and associated draft water quality objectives are currently under review.

For the purposes of this assessment, existing surface water quality has been compared to the ANZECC guidelines as they provide established water quality guidelines for each of the relevant environmental values.

13.2.4 Surface Water Quality

Baseline Monitoring Program

The DNRM maintains a network of regional surface water monitoring stations throughout the Burdekin Basin. Several years of monitoring data has been collected during flow events at locations along the Belyando River and its tributaries, the Suttor River and the receiving waters of the Burdekin Falls Dam and lower Burdekin River. This data provides a robust baseline dataset for a range of physico-chemical parameters over the period from 2005 to 2013 at locations downstream of the project site. Parameters monitored include electrical conductivity (EC), pH, total suspended solids, turbidity and a range of toxicants. It is understood that the monitoring data provided by the DNRM has been collected in accordance with relevant guidelines and standards, and that the reported data are representative of conditions in the receiving waters. The relevant DNRM monitoring stations are shown on Figure 13-1.

The baseline surface water quality dataset has been supplemented by local water quality sampling data for North Creek and the Belyando River upstream of the North Creek confluence (GHD, 2013). Monitoring locations are shown on Figure 13-2. Samples were collected from these locations on at least five occasions between October 2012 and April 2013. This local water quality sampling data is reported to be representative of wet season conditions at these locations.

As discussed previously, the project site is remote and is located at the head of the catchments. It has highly ephemeral, short duration, surface water flows. These factors severely limit the ability for any regular sampling of surface water flows from the project site. Site surface water quality was sampled from remnant surface water during the aquatic ecology field surveys in May and October/November 2012. The results of this water quality monitoring are presented in Section 10 – Aquatic Ecology and indicate that water quality in the ephemeral drainage lines, seasonal wetlands and dams was turbid and had elevated levels of nitrogen and phosphorus as a result of stock access. As these water quality results are from remnant ponded surface water they are not representative of the quality of site surface water flows and are therefore not presented in this section.

The rationale for selection of representative monitoring locations for the project is as follows:

1. North Creek – opportunistic monitoring site located downstream of the Eight Mile Creek confluence. This site provides water quality data immediately downstream of the project site.
2. Belyando River – opportunistic monitoring site located downstream of the Carmichael River confluence and upstream of the North Creek confluence. This site provides indicative water quality data for the Belyando River upstream of any drainage from the project site.
3. Belyando River – long-term monitoring site located at the Gregory Developmental Road crossing, downstream of North Creek and Tomahawk Creek, and upstream of the Suttor River confluence. This site is considered representative of receiving water flows and background water quality in the Belyando River catchment.
4. Suttor River – long-term monitoring site located at St. Anns, downstream of the Belyando River confluence and upstream of the Burdekin Falls Dam. This site is considered representative of background water quality in the Suttor River catchment.
5. Burdekin Falls Dam – long-term monitoring site located at the Burdekin Falls Dam outflow. This site is considered representative of background water quality in the Burdekin Falls Dam.

The location of these monitoring sites are shown in Figures 13-1 and 13-2.

Baseline Water Quality Assessment

A statistical summary of the water quality measured from these sites is provided in Attachment 13-1. Relevant guideline values, primarily sourced from the ANZECC guidelines, the QWQG and the Department of Environment and Heritage Protection (EHP) Model Mining Conditions, are also quoted for reference.

Nutrient concentrations in the Belyando and Suttor Rivers are typically slightly elevated, and decrease at the Burdekin Falls Dam. Suspended sediments, turbidity and sulphate all show the same trend.

As discussed above, the Belyando Basin and the wider catchment of the Burdekin Falls Dam are characterised by naturally elevated suspended sediment loads in watercourses. The Burdekin Falls Dam acts to attenuate natural sediment loads prior to discharge into the lower Burdekin Basin. The mechanism of sediment attenuation will also act to reduce particulate nutrient loads and sulphate concentrations. The Burdekin Falls Dam receives a low proportion of its throughput from the Belyando-Suttor catchment, which acts to further dilute any inputs from the Belyando-Suttor catchment (NQ Dry Tropics, 2009).

Nutrient metabolism and breakdown typically exerts an oxygen demand. The decrease in nutrient concentrations at the Burdekin Falls Dam (and associated decrease in oxygen demand) is reflected in the observed increase in dissolved oxygen concentrations at the Burdekin Falls Dam.

Long-term salinity (as electrical conductivity and total dissolved solids), pH, alkalinity and major ion levels are generally consistent throughout the regional drainage network and within the expected range for upland freshwater streams.

Natural background concentrations of aluminium, copper and zinc exceed the most conservative of the quoted guidelines at all monitoring locations. Iron is also present in the Belyando and Suttor Rivers at concentrations above the most conservative quoted guidelines. All other toxicant concentrations are within the quoted guidelines.

All monitored values are within applicable guidelines for cattle watering and irrigated agriculture.

13.3 WATER MANAGEMENT STRATEGIES

The proposed management strategy for each type of water generated by the project is dependent on the quality of the water and is designed to prevent any adverse impacts on downstream surface water values. The requirements to maximise the reuse of mine-affected water for water supply, minimise the demand for external water supply and minimise the risk of uncontrolled discharge of any mine-affected water from the project site were also key considerations in the selection of appropriate water management strategies.

The project will require the management of the following waters:

- Underground mine pit water comprising:
  - Groundwater inflow to the underground workings; and
  - Water recycled from underground operations.
- Open cut mine pit water comprising:
  - Groundwater inflow to the open cut pit; and
  - Runoff from the open cut pit catchment.
- Return water from the tailings storage facility (TSF) comprising;
  - Supernatant recovered from the deposited tailings:
  - Rainfall and runoff from the contained internal TSF catchment; and
  - Runoff from the power station waste storage facility (PSWSF) which will be collected in sumps and transferred to the TSF decant pond.

- Runoff from areas disturbed by project activities including overburden emplacement areas and mine infrastructure areas;
- Runoff from areas affected by mine subsidence; and
- Runoff from areas undisturbed by project activities.

The proposed management strategies for each of the waters generated by the project are discussed in the following sections. Section 13.5 describes the proposed system for the management of mine-affected waters generated by the project.

The management of sewage effluent generated by the project is discussed separately in Section 21 – Non-Mining Waste Management.

13.3.1 Underground Mine Pit Water

Underground mine pit water comprises groundwater inflow to the underground workings and recycled water supply from longwall mining operations.

Predicted groundwater inflow to the underground workings is discussed in detail in Section 12 – Groundwater. Groundwater inflow to the underground workings will predominantly occur from the coal seams. Groundwater modelling (*Groundwater Report*, Appendix I) predicts that the rate of groundwater inflow to mine workings will generally increase as the mine excavation increases in area and depth. Modelled groundwater inflows to the Northern Underground peak at a rate of 1,410 Mega Litres per annum (MLpa) at Project Year 16. Modelled inflows to the Southern Underground peak at 1,520 MLpa at Project Year 13. A factor of 0.6 has been applied to these modelled inflow rates to convert them to dewatering volumes. This accounts for losses due to evaporation and infiltration to the walls and floor of the underground workings.

Up to approximately 250 MLpa of underground water supply is estimated to be recycled from each operating longwall. This water will collect in underground sumps with groundwater inflow.

Underground mine pit water quality will be variable and dependent on the relative contributions of recycled raw water and groundwater inflow. The *Groundwater Report* (Appendix I) states that salinity is the primary consideration with respect to groundwater inflow quality. The report presents water quality data that shows coal seam groundwater to be fresh to moderately saline. Given groundwater will make up only a portion of the total pit water, the salinity of the pit water will be lower than the groundwater. Pit water pumped from the underground mines may also contain elevated levels of suspended sediment.

The management of underground mine pit water will involve pumping it to the surface, containment in dedicated on-site storage dams and use as mine water supply. Both the Northern and Southern Undergrounds will have pit water dams at their respective mine industrial areas (MIAs). Pit water from the undergrounds will be pumped to the MIA pit water dams. Water stored in the MIA pit water dams will be pumped to a dedicated Mine Water Dam for storage and reuse as mine water supply. The pit water dams will each have nil catchment and will be operated with freeboard above maximum operating storage levels to ensure nil overflow. The location of these dams is shown on Figure 13-4. Dam design principles and operation are described in Section 13.5.3.

13.3.2 Open Cut Mine Pit Water

Open cut mine pit water comprises groundwater inflow to the open cut mine and runoff from the open cut pit catchment.

Predicted groundwater inflow to the open cut mine is discussed in detail in Section 12 – Groundwater. As with groundwater inflows to the underground mines, the rate of inflow has been determined through groundwater modelling. Modelled groundwater inflows to the open cut mine will generally increase with the size of the excavation and are predicted to peak at a rate of approximately 4,070 MLpa. Groundwater dewatering volumes account for losses due to surface wetting, evaporation and infiltration to the walls and floor of the pit.

The open cut pit catchment will increase progressively over the mine life as the open cut mine develops. The pit catchment area will include the active pit area as well as any areas of the overburden emplacement and areas above the highwall that cannot be drained around or away from the pit. The open cut mine drainage strategy is designed to limit the catchment area of the open cut pit. This strategy will minimise potential disruption to production due to flooding of the pit and also minimise the generation of large volumes of mine-affected pit water from rainfall runoff. The open cut mine drainage strategy is described in Section 13.4 and illustrated in Figures 13-4 to 13-6.

Open cut pit water quality will vary depending on the relative contributions from groundwater inflow and rainfall runoff. As discussed in Section 13.3.1, groundwater can be moderately saline, whilst rainfall runoff will be relatively fresh.

Pit water will drain to collection sumps in the floor of the open cut pit. The management of open cut mine pit water will involve containment in dedicated on-site storage dams and use as mine water supply. A series of four open cut pit water dams will be located along the length of the open cut mining area, near the main haul road (Figures 13-4 to 13-6). Water from pit sumps along the length of the active pit will be transferred to these dams. Water from these dams will then be pumped to the Mine Water Dam for storage and use as mine water supply. The pit water dams will each have nil catchment and will be operated with freeboard above maximum operating storage levels to ensure nil overflow. Dam design principles and operation are described in Section 13.5.3.

During extended rainfall events the open cut pit will collect significant volumes of rainfall runoff that are not feasible to store in site mine water storage dams. Following such events, in order to dewater the open cut pits and allow continuing production, it will be necessary for accumulated pit water to be discharged from site under controlled conditions. The controlled discharge of pit water is discussed in more detail in Section 13.5.5.

13.3.3 TSF and PSWSF Return Water

The project will involve the construction of a conventional wet TSF and an adjacent PSWSF that will store dry waste from the power station for the first ten years of operations. The operation of the TSF and PSWSF is described in detail in Section 7 – Tailings and Power Station Waste Storage Facilities. The locations of the TSF and PSWSF are shown in Figure 13-4.

Geochemical characterisation of the tailings and power station waste materials was completed as part of the *Geochemistry Report* (Appendix D). The geochemical assessment concluded that both tailings material and power station waste are likely to be relatively benign and generate neutral to alkaline, low to moderate salinity runoff.

The TSF will be developed progressively over the 50 year project life. When completed it will cover an area of approximately 603 ha. The catchment of the active TSF area will be isolated by the TSF embankment and temporary diversion drains in the period prior to completion of construction of the embankment around the TSF perimeter. The PSWSF will also be developed progressively over the first 10 years of the project. When completed it will cover an area of approximately 80 ha. The catchment of the active PSWSF will also be isolated by perimeter diversion drains. The progressive development of these facilities is illustrated in Figures 13-4 to 13-6.

Tailings will be pumped to the TSF from the Coal Handling and Preparation Plant (CHPP) as a slurry. Tailings solids will settle out of suspension within the TSF and supernatant will collect in a decant pond maintained at the low point within the TSF. Rainfall runoff from within the TSF will also collect within the TSF decant pond.

The PSWSF will be developed by placing dry power station waste using trucks, similar to an out-of-pit overburden emplacement. The PSWSF will be developed such that surface runoff from active emplacement areas drains to internal collection sumps. Rainfall runoff that collects in these sumps will be pumped to the adjacent TSF and will report to the TSF decant pond.

A perimeter seepage collection drain will be installed at the downstream toe of the TSF embankment and the external PSWSF slopes. Any seepage from these facilities will be collected in a series of sumps and pumped to the TSF decant pond.

The management of TSF return water will involve containment within the TSF decant pond and the Return Water Dam. The TSF and decant pond will be constructed and operated such that sufficient freeboard is maintained above the deposited tailings and decant pond to contain rainfall runoff and prevent any potential overflows. A pontoon mounted pump will be moored in the TSF decant pond. This pump will maintain a low water level in the TSF decant pond by transferring water to the Return Water Dam. The Return Water Dam storage will be a priority water supply for the CHPP. The location of the Return Water Dam is shown on Figure 13-4. Dam design principles and operation are described in Section 13.5.3.

13.3.4 Runoff from Areas Disturbed by Mining Activities

Runoff from Overburden Emplacement Areas

The project will involve the progressive development and rehabilitation of overburden emplacement areas. The progressive development and rehabilitation of these areas is shown on Figures 13-4 to 13-7.

Geochemical characterisation of the overburden material was completed as part of the *Geochemistry Report* (Appendix D). The geochemical assessment concluded that overburden material is likely to be relatively benign and generate low salinity runoff. Based on the overburden leach test results, the high levels of dilution of any overburden leachate in fresh rainfall runoff would ensure that overburden runoff would meet ANZECC guidelines for aquatic ecosystem protection and would therefore be suitable for passive drainage from site. Runoff from unrehabilitated overburden emplacement areas may however contain elevated levels of suspended sediment. Runoff from these areas will be captured in collection drains and directed through sediment traps and sediment dams for control of suspended sediment prior to discharge from site. Diversion drains will also be installed to divert overland flow from upstream areas around the overburden emplacement areas.

Rehabilitation of the overburden emplacements will be undertaken progressively over the mine life and will be completed at the end of open cut mining operations. Rehabilitation will involve reshaping of the overburden emplacements to a stable final landform that will promote surface runoff. Contour drains will be constructed on the rehabilitated external slopes to prevent erosion of the final landform. Rehabilitated slopes will generate clean runoff that will be allowed to drain passively to downstream overland flowpaths. Overburden emplacement area rehabilitation is discussed in detail in Section 8 – Rehabilitation.

The progressive development of the overburden emplacement drainage and sediment control system is illustrated in Figures 13-4 to 13-6. This drainage system will be designed and implemented in accordance with an Erosion and Sediment Control Plan (ESCP). The ESCP is discussed in detail in Section 24 – Environmental Management.

Runoff from Mine Infrastructure Areas

The project mine infrastructure areas are shown in Figures 13-4 to 13-6 and include the following:

- Northern Underground and Southern Underground MIAs;
- Open Cut MIA including vehicle wash down, servicing and refuelling facilities;
- Stockpiles including raw coal, product coal, and coal reject stockpiles;
- CHPP and CHPP Run-of-Mine (ROM) loading station;
- Power station; and
- Train loadout.

Runoff from these areas may contain elevated levels of suspended sediment and possibly hydrocarbons or other chemicals. These infrastructure area catchments will be isolated with diversion drains and/or bunding, where necessary. Any minor bunding of the infrastructure area catchments will not involve floodplain management measures or levees and there are no significant environmental, safety or wider economic consequences associated with a potential failure of these bunds. On this basis these bunds are not considered regulated structures. Runoff from these areas will be collected in collection drains, directed through sediment traps (and oil separators where hydrocarbons are potentially present), and collected in a dedicated catch dam. Catch dams will be maintained with full storage capacity available for the collection of rainfall runoff. Any collected rainfall runoff will be transferred to a central Industrial Area Dam for storage and use as mine water supply. Each of the catch dams has been sized to ensure they have a low probability of overflow. The location of the catch dams and the Industrial Area Dam are shown on Figure 13-4. Dam design principles and operation are described in Section 13.5.3.

The following ancillary infrastructure areas are also proposed:

- Laydown areas;
- Topsoil stockpiles;
- A workforce accommodation village; and
- A private airstrip.

Runoff from these ancillary infrastructure areas may contain elevated levels of suspended sediment. Runoff from these areas will be captured in collection drains and directed through sediment traps and sediment dams for control of suspended sediment prior to discharge from site. Diversion drains will be installed to divert overland flow from upstream areas around these areas. These works will be designed and constructed in accordance with an ESCP.

Similarly, during construction, runoff from all disturbed mine infrastructure areas may contain elevated levels of suspended sediment. Runoff from these areas will be collected, treated and passively discharged as outlined for ancillary infrastructure areas. These works will be designed and constructed in accordance with a construction phase ESCP.

13.3.5 Runoff from Areas Undisturbed by Mining Activities

Wherever possible, runoff from undisturbed areas will be diverted around areas disturbed by mining activities and allowed to drain from site.

A drainage strategy for the open cut mining area and mine infrastructure area has been developed as an integral component of project planning. The drainage strategy was designed to ensure suitable drainage arrangements and associated flood protection are provided for both the operations phase and post mine closure. The site drainage strategy involves diverting clean runoff from truncated catchment areas upstream of the open cut pit around the open cut mine and mine infrastructure area. This will be achieved by the construction of permanent drains along the final highwall of the open cut pit and the establishment of drainage corridors at the northern and southern ends of the open cut mine and infrastructure areas (Figures 13-4 to 13-6).

The highwall drains will minimise the contributing catchment areas of the open cut pits during operations. This will provide flood protection for the operating pits and limit the generation of mine-affected pit water. The highwall drains and the northern and southern drainage corridors will remain in place after mine closure (Figure 13-7). They have therefore been designed to ensure they will remain stable in the long term. They have been designed with capacity to convey the peak flows from the Probable Maximum Flood (PMF). The highwall drain design principles are discussed in Section 13.4.1.

The highwall drains will isolate the open cut mine and mine infrastructure area catchment. Diversion drains will be constructed to manage the flow of clean runoff from undisturbed areas through the open cut mine and mine infrastructure area catchment. Diverted runoff will be directed to natural overland flowpaths downstream of the open cut mine and mine infrastructure area.

Clean runoff from the northern and southern drainage corridors will flow to the headwaters of Tomahawk Creek and North Creek, respectively.

The permanent highwall drains will create temporary isolated undisturbed catchment areas upstream of the open cut pit during the operations phase. Temporary diversion drains will be installed to manage drainage from these areas and protect the active pit highwall. Runoff from these limited catchment areas will be diverted around the open cut pits, or where this is not feasible, to temporary highwall dams. Runoff collected in temporary highwall dams may be used for dust suppression supply. Any overflow from these dams would report to the open cut pit.

The staged development of the drainage arrangement is described in detail in Section 13.4.2.

13.3.6 Runoff from Subsided Areas

Subsidence from longwall mining can lead to localised alteration of drainage paths and ponding of water in shallow surface depressions (Figure 13-8).

Subsidence effects on surface drainage will be mitigated by the installation of minor remedial drainage earthworks to re-establish free drainage. These drainage works are described in Section 13.4.1.

13.4 SITE DRAINAGE MANAGEMENT

A conceptual site drainage plan has been developed for the project. The objectives of the site drainage management plan are as follows:

- Where possible, divert clean runoff from undisturbed areas around areas disturbed by mining activities and allow to drain from the site;
- Control suspended sediment in site drainage water and potential downstream sedimentation through the collection of sediment-affected water and direction through sediment control structures in accordance with an ESCP;
- Contain mine-affected water in on-site mine water storages for use as mine water supply;
- Controlled release of any excess mine-affected water in accordance with the EHP Model Mining Conditions, which are designed to ensure the protection of downstream environmental values;
- Provide an adequate level of flood protection for mine infrastructure and the open cut pit; and
- Establish a free-draining post mining landform (with the exception of the final void).

The staged site drainage plans and design principles are described in detail in the following sections and illustrated in Figures 13-4 to 13-7.

13.4.1 Site Drainage Plan Components and Design Principles

Drainage infrastructure including diversion drains, collection drains, sediment dams and sediment traps will be constructed progressively as the operations expand over the life of the mine. Site drainage infrastructure will be designed in accordance with relevant engineering guidelines and standards. Licences for dam structures will be applied for as necessary. No creek diversions will be necessary for construction of the proposed mine water management system. Key components of the proposed site drainage system are described in the following sections.

Highwall Drains

The highwall drains have been designed and located to minimise the catchment area draining into the open cut pits and final voids. The highwall drains will be permanent structures and will remain in place post mining. Consequently they have been designed with sufficient capacity to convey the peak flows from the PMF from the critical storm event. They will provide PMF flood immunity for the active open cut pits and final voids.

The drains have been designed to:

- Replicate the key hydraulic characteristics of the existing drainage features including stream velocity, bed shear and stream power, as far as is practical; and

- Operate within relevant hydraulic design criteria specified in the DNRM *Guideline – Works that interfere with water in a watercourse: watercourse diversions* (DNRM, 2014).

The drains will typically be constructed to a 1:100 cross fall from the edge of the drain to the invert with 1(V):3(H) cut slope for the batters. Sections of both the northern and southern highwall drains will be located over areas that will be subject to subsidence from underground longwall mining. The drains have been scheduled to be constructed after any subsidence is complete and the constructed drain sections will therefore not be subsided.

Detailed modelling undertaken as part of the design process (*Open Cut Mine Drainage Report*, Appendix J) shows that average flow velocities, stream power and bed shear in the highwall drains are generally well within the applicable hydraulic design criteria. Based upon these design specifications, the drains will be stable in the long-term.

Diversion and Collection Drains

Temporary and permanent diversion drains will be constructed to isolate the contained catchments of the open cut pits and mine infrastructure areas and to divert runoff from undisturbed areas through the site. Diversion drains will typically be contour drains constructed with sufficient capacity to convey runoff from the 20 year average recurrence interval (ARI) critical storm event. The specific design capacity of each drain will be determined at the detailed design stage depending upon the contributing catchment, design life of the drain and overtopping risk.

Collection drains will be constructed around the perimeter of contained mine infrastructure catchments to collect runoff from the isolated catchments and direct it to catch dams. Collection drains will also be installed at the toe of the active overburden emplacements to direct runoff to sediment dams. The collection drains will typically have sufficient capacity to convey runoff from 20 year ARI critical storm event. The collection drains for contained catchments will typically be excavated table drains, with an external bund to provide additional freeboard for extreme events (e.g. a more than 100 year ARI storm event).

Longitudinal grades will be typically 1% and cross-section batters will be constructed to stable slopes and revegetated to minimise erosion. Any steeper sections will be constructed with velocity control structures or scour protection. Discharge points to natural drainage lines will be designed with energy dissipation measures, where necessary, to prevent any scouring and ensure stability.

Rehabilitation Contour Drains

Contour drains will be installed on all rehabilitated overburden emplacement, TSF and PSWSF slopes. Contour drains will minimise the potential for erosion by limiting the effective slope length and the velocity of runoff. These drains will be installed to collect runoff from rehabilitated slopes and direct this runoff to the natural overland flow paths.

The design and construction of these drains will be similar to diversion drains. Contour drains will generally be constructed at regular intervals down a slope. Smaller “V” drains will also be constructed in between the larger contour drains at regular intervals down the slope to limit the maximum effective slope length. The “V” drains will have sufficient capacity to convey the peak runoff flow from the 20 year ARI critical storm event. The precise location of the contour drains and intermediate “V” drains will be determined during detailed rehabilitation design.

A detailed description of the TSF and PSWSF final landforms is provided in Section 8 – Rehabilitation. A decommissioning plan for the TSF and PSWSF will be prepared as part of detailed design in accordance with the EHP Model Mining Conditions. Detailed design of drains that will convey runoff from the top of the rehabilitated TSF and PSWSF landforms to the base will be conducted by a Registered Professional Engineer of Queensland. These drains will be designed to provide suitable capacity and scour protection using standard and proven techniques to mitigate the potential for erosion and ensure the long-term stability of the decommissioned landforms.

Temporary Highwall Dams

Temporary highwall dams will be installed adjacent to the active highwall of the open cut pit to catch runoff from small truncated undisturbed catchment areas which is unable to be directed away from the pit by diversion drains. These dams will limit the uncontrolled overflow of runoff over the active pit highwall. Any overflow from these dams will report directly to the pit and would be incorporated into pit water which will be contained on site for mine water supply.

These dams will be temporary and the capacity and design of these dams will be dependent on the terrain and the size of the contributing catchment area. With these considerations taken into account the catch dams will generally be as large as practical. These dams will be installed progressively as the open cut pit advances.

Sediment Control Structures

Sediment dams will be constructed downstream of all areas disturbed by mining activities to control suspended sediment from site runoff prior to passive drainage from site. Site runoff will generally be directed to one or more sediment dams by diversion drains or catch drains prior to draining from the site. In addition to sediment dams, a network of smaller sediment traps will also be installed close to any significant sources of sediment. This will effectively achieve a staged approach to control of suspended sediment in site drainage water with coarser sediments being trapped close to the source and finer sediments trapped in the larger sediment dams. Sediment traps will be installed progressively over the life of the mine immediately downstream of any bare earthworks areas. They will generally be constructed as excavated pits at a size readily desilted by an excavator. The precise number and location of sediment traps will be determined during preparation of the detailed ESCP. The indicative location of sediment dams on sediment-affected catch drains is shown on the conceptual site drainage plans (Figures 13-4 to 13-6).

Sediment dams will be designed and constructed generally in accordance with the Queensland *Urban Drainage Manual*. The detailed design of each dam will be dependent on specific site conditions and the design life of the dam, but will typically be designed to manage inputs from the critical 10 year ARI storm event. All sediment traps and sediment dams will be regularly desilted to ensure their continued effective operation. The ESCP is discussed in more detail in Section 24 – Environmental Management.

Remedial Drains for Subsidence Depressions

Ponding of surface water due to underground mine subsidence will be remediated by the installation of minor remedial drainage earthworks to re-establish free drainage. Drainage works may include the construction of excavated trapezoidal drainage channels, designed with sufficient capacity to cater for contributing catchments and with stable batter slopes. These channels would enable free drainage of subsidence depressions. Drainage channels will be located to avoid sensitive features and vegetation communities, as far as practicable.

The location of conceptual remedial drainage works are shown in Figure 13-8. These have been prepared based on contours of the subsided surface calculated from the project's subsidence predictions (discussed in Section 6 – Subsidence). While the subsidence predictions are sufficiently accurate to determine the potential extent of impacts on surface drainage and conceptual remedial drainage works, the detailed design of the minor remedial drainage works will be based on an accurate survey of the actual subsided ground surface. These drainage works would be conducted in accordance with the *Draft Subsidence Management Plan* (Appendix B) and the ESCP.

13.4.2 Staged Drainage Description

An overview of the conceptual site drainage plan for representative stages of mine development is provided in the following sections.

Project Year 5

The conceptual site drainage plan for Project Year 5 is shown on Figure 13-4. At this stage, the mine infrastructure has been constructed and open cut mining is in the early stages of operations.

During construction the northern highwall drain will be installed to divert overland flows from unnamed gully sub-catchments in the headwaters of Tomahawk Creek around the northern extent of the open cut mine and infrastructure area. The northern highwall drain will discharge to the northern drainage corridor which contains existing upper tributaries of Tomahawk Creek. The northern highwall drain will be a permanent drain that will remain operational for the life of the mine.

The upstream section the southern highwall drain will be installed to divert overland flows from unnamed gully sub-catchments in the headwaters of North Creek and Tomahawk Creek to the south of the open cut mining area. This initial section of the southern highwall drain will discharge to the southern drainage corridor which contains upper tributaries of North Creek.

The on-site rail line and mine access road will cross the southern drainage corridor at the eastern boundary of the project site. A series of drainage culverts will be installed in the rail and road embankments to allow drainage along natural drainage lines. The culverts will be designed so that the road and rail have flood protection from the 50 year ARI flood event in the southern drainage corridor. These culverts will remain operational for the life of the mine.

Diversion drains will be installed to the west of the open cut pit to divert runoff from undisturbed catchment areas away from the pits. Highwall dams will also be installed in any areas where upstream drainage cannot be diverted from the highwall. These dams will limit the uncontrolled overflow of runoff over the active pit highwall.

The majority of the initial open cut mining activity prior to Project Year 5 is in the north of the open cut mine area. Temporary collection drains and sediment dams will be installed at the toe of the active overburden emplacement areas to control runoff from these areas. Temporary diversion drains will be constructed to convey runoff from undisturbed areas and discharge from sediment dams through the north and south of the mine infrastructure area. A northern diversion drain will direct drainage around the open cut MIA and around the TSF, into an upper tributary of Tomahawk Creek. A southern diversion drain will direct drainage to the north of the workforce accommodation village and airstrip to the headwaters of North Creek, via a culvert. These diversion drains will remain operational for the life of the mine.

During construction, disturbed areas within the mine infrastructure area will be isolated with diversion drains. These diversion drains will divert clean runoff around disturbed areas within the mine infrastructure area and allow clean runoff to flow to natural downstream flowpaths. Clean runoff from the northern and southern parts of the mine infrastructure area will be diverted to the headwaters of Tomahawk Creek and North Creek, respectively.

Project Year 15

The conceptual site drainage plan for Project Year 15 is shown on Figure 13-5. This development stage is approximately half way through the life of the open cut mine.

The open cut mining area at this stage has extended to the west and the south. The downstream section of the southern highwall drain has been installed to divert runoff from truncated upstream catchments around the ultimate southern limit of the open cut pit. The southern highwall drain will discharge to drainage lines within the southern drainage corridor. The northern highwall drain arrangement is unchanged.

The temporary highwall drains and highwall dams west of the active pit highwall have been realigned to control runoff from the undisturbed upstream catchments. The overburden emplacement collection drains and sediment dams have been realigned to the larger overburden emplacement area.

The majority of the southern overburden emplacement area has been rehabilitated. Contour drains have been installed to control runoff from the rehabilitated slopes and minimise slope erosion. Collection drains have been installed at the toe of the rehabilitated slopes to collect runoff and divert it into the existing diversion drain north of the workforce accommodation village.

At this stage the TSF embankment has been constructed around the perimeter of the TSF and the PSWSF has been completed and rehabilitated. The diversion drains around these facilities have been realigned to suit.

Project Year 30

The conceptual site drainage plan for Project Year 30 is shown in Figure 13-6. This development stage is close to end of open cut mine operations.

The open cut mining area at this stage has extended further to the west and the south to its ultimate limits. The temporary highwall drains and highwall dams west of the active pit highwall have been realigned to control runoff from the undisturbed upstream catchments. The overburden emplacement collection drains and sediment dams have been realigned to the larger overburden emplacement area.

The majority of the eastern portion of the overburden emplacement area has been rehabilitated. Contour drains have been installed to control runoff from the rehabilitated slopes and minimise slope erosion. Collection drains have been installed at the toe of the rehabilitated slopes to collect runoff and divert it into the existing diversion drains through the mine infrastructure area.

Mine Closure

The mine closure drainage plan, based on the final landform for the open cut mine and mine infrastructure area, is shown in Figure 13-7. The post mining landform for the northern area of the project site is shown on Figure 13-8. The impact on the landform in this northern area will be limited to subsidence, minor remedial drainage works and minor infrastructure associated with surface access above the Northern Underground.

The final landform will include the rehabilitated overburden emplacement areas, TSF and PSWSF, remnant final voids and rehabilitated mine infrastructure areas after the removal of all mine infrastructure. The highwall drains will remain post mining to limit the final void catchment areas. The northern and southern drainage corridors will also continue to convey any discharge from the highwall drains to the downstream natural drainage system. The decommissioned mine infrastructure area will be profiled with drainage installed to discharge to the downstream natural drainage lines. All areas of the project site will be free draining with the exception of the remnant final voids. Lakes will form in the final voids and will reach an equilibrium level well below the spill point (Section 13.6.6).

13.5 WATER MANAGEMENT SYSTEM

The proposed mine water management system logic, including water supplies, water demands and key water supply storages, is illustrated in Figure 13-9. The system involves the use of mine-affected waters, described in Section 13.3, as mine water supply and an external raw water supply to meet high quality water supply requirements and make up any shortfall in the site water balance.

The mine water management system is described in the following sections along with the water balance for the proposed operations.

13.5.1 Water Supplies

Sources of water supply for the project are as follows:

- Mine-affected underground pit water including:
  - Variable groundwater dewatering volumes of up to approximately 850 MLpa in the Northern Underground and 920 MLpa in the Southern Underground; and
  - Recycled underground raw water supply of up to approximately 500 MLpa in the Northern Underground and 250 MLpa in the Southern Underground.
- Mine-affected open cut pit water including:
  - Variable groundwater dewatering volumes of up to approximately 2,440 MLpa; and
  - Variable rainfall runoff to the open cut pit catchments.
- Mine-affected TSF return water including:
  - Variable recovered supernatant from the deposited tailings of up to approximately 1,500 MLpa;
  - Variable rainfall runoff from the TSF area; and

  - Variable rainfall runoff from the PSWSF area.
- Variable mine-affected runoff quantities from contained infrastructure area catchments including:
  - Underground and open cut MIAs;
  - Coal and reject stockpile areas;
  - CHPP and CHPP ROM loading station;
  - Power station; and
  - Train loadout.
- External raw water supply, as required.

Groundwater inflow volumes are discussed in Section 12 – Groundwater. The rate of groundwater inflow to mine workings generally increases as the mine excavations increase in area and depth. The mine groundwater dewatering volumes have been predicted from groundwater modelling results presented in the *Groundwater Report* (Appendix I).

Rainfall runoff volumes will be dependent on the contained catchment areas and climatic factors (including rainfall and evaporation). Contained catchment areas in the mine infrastructure area will generally remain constant once constructed. The mine waste storage facilities and open cut mine catchments will vary as these areas are developed over the life of the mine. Key stages in the development of these areas are discussed in Section 13.3 and site drainage plans are shown in Figures 13-4 to 13-6. The staged development of these areas has been adopted for this assessment in order to capture the variation in runoff contribution over the life of the mine.

Rainfall runoff captured as mine-affected water from all contributing catchment areas has been modelled based on daily rainfall data. This is discussed in detail in the *Water Management System Modelling Report* (Appendix K).

Additional external raw water supply will be required to supply demands which require high water quality and during dry periods when mine water stored on site is insufficient to meet mine water demands.

13.5.2 Water Demands

Water demands and losses for the project are typically variable over the life of the project and include the following:

- Underground mine supply comprising:
  - Up to approximately 1,250 MLpa of raw water to the Northern Underground; and
  - Up to approximately 630 MLpa of raw water to the Southern Underground.
- Vehicle washdown of up to approximately 110 MLpa of raw water.
- Power station supply of up to approximately 3,000 MLpa of raw water.
- Water treatment plant supply of up to approximately 270 MLpa of raw water to be treated to provide potable water supply for the project.
- CHPP water supply of up to approximately 7,300 MLpa preferentially sourced from TSF return water and other mine-affected water supplies. External raw water supply will be used where insufficient mine-affected water supply is available.
- Dust suppression water supply of up to approximately 1,810 MLpa for areas including haul roads, coal stockpiles and conveyor transfers. This will be preferentially supplied by mine-affected water. External raw water supply will be used where insufficient mine-affected water supply is available.

- Controlled discharge of mine-affected water. Variable quantities of mine-affected water will need to be discharged in accordance with the EHP's model EA discharge conditions following extended rainfall periods when accumulated open cut pit water volumes exceed the site pit water storage capacity.

During the construction phase of the project, the primary water demands will be dust suppression for disturbed areas, with potable water and washdown generating secondary water demands. The power station and CHPP will not be operational during the construction phase and will not generate a water demand. The construction phase disturbance footprint (i.e. the area requiring dust suppression) will be significantly smaller than during peak open cut mining operations, and construction activities will involve less mobile equipment than peak open cut mining operations. The total peak construction phase water demand is estimated to be approximately 1,685 MLpa comprising:

- Dust suppression water supply of up to approximately 1,530 MLpa; and
- Vehicle washdown of up to approximately 65 MLpa;
- Water treatment plant supply of up to approximately 90 MLpa.

The construction phase water demand will be significantly less than the peak operations demand. Further details of the construction phase water supplies and demands are provided in the *Mine Water Management System Modelling Report* (Appendix K).

13.5.3 Mine Water Dams

Mine water dams will be constructed on the project site to collect and contain mine-affected water. The key mine water dams and their operating logic are shown in Figure 13-9, and are described as follows:

- Return Water Dam – this dam will be used to store return water transferred from the TSF decant pond. It will have sufficient storage capacity to enable the TSF decant pond to be maintained at a low water level, ensuring there is no risk of an overflow from the TSF. This dam will be a priority source of water supply to the CHPP. This dam will have nil external catchment and will be operated with a minimum freeboard to ensure it does not overflow.
- Mine Water Dam – this dam will be used to store pit water generated from the underground and the open cut mines. Pit water will be pumped to the dam from the underground workings and the open cut pits via intermediate pit water dams. This dam will be a primary source of dust suppression water supply and a secondary source of water supply to the CHPP. This dam (and the intermediate pit water dams) will have nil external catchment and will be operated with a minimum freeboard to ensure it does not overflow. In order to minimise the accumulation of runoff in the open cut pits during extended wet periods, pit water will be transferred to this storage as a high priority and may accumulate in this dam during extended wet periods. The dam will have a controlled release pipe to enable the controlled release of pit water in accordance with the EHP model EA discharge conditions. Controlled releases will be necessary following extended wet periods where accumulated runoff in the open cut pits exceeds the site pit water storage capacity. The estimated frequency and volume of controlled releases from this dam are discussed in Section 13.5.5.
- Industrial Area Dam and mine infrastructure area catch dams – the Industrial Area Dam will be used to store water transferred from numerous mine infrastructure area catch dams (Table 13-3). The catch dams will collect runoff draining from contained infrastructure area catchments. Any runoff collected in the catch dams will immediately be transferred to the Industrial Area Dam to ensure they are maintained with maximum storage capacity to contain rainfall runoff with a low probability of overflow. The Industrial Area Dam will be a primary source of dust suppression water and a secondary source of water supply to the CHPP. This dam will have nil external catchment and will be operated with a minimum freeboard to ensure it does not overflow. Due to the transfer of water from catch dams, water may accumulate in this dam during extended wet periods.

- Raw Water Dam – this dam will be a buffer storage for an external raw water supply, with nil external catchment. This dam will be the primary source of raw water supply to the underground mine, vehicle washdown, power station and water treatment plant. This dam will be a secondary source of water supply for the CHPP and dust suppression.

The location of these dams is shown in Figure 13-4. All dams will be designed and constructed in accordance with relevant design standards and licence requirements, including standards defined in the Water Act. Designs will adequately address the structural integrity of containment walls during climatic extremes, including drought and flood.

A preliminary consequence category assessment has been undertaken for the proposed mine water dams in accordance with the EHP's *Guideline: Structures which are dams or levees constructed as part of environmentally relevant activities* and accompanying *Manual for Assessing Hazard Consequence and Hydraulic Performance of Structures* (the Manual) to determine the regulatory requirements in relation to the design and certification of dams constructed as part of environmentally relevant activities (ERAs) under the *Environmental Protection Act 1994* (EP Act). The design characteristics for the proposed mine water dams have been assessed against the consequence categories specified in the Manual. The findings are summarised as follows:

- Dams are located such that loss of life is not expected as a result of dam failure.
- The closest downstream dam to the project site that is used for drinking water supply and irrigated agriculture is the Burdekin Falls Dam. This dam is approximately 255 km downstream of the project site and has a full storage capacity of 1,860 GL (i.e. over 1,000 times the capacity of the proposed Mine Water Dam). In the unlikely event of a failure of a mine-affected water storage dam, the relatively minor volume of mine-affected water is not likely to adversely affect water quality at this dam. On this basis, it is assessed that:
  - No significant agricultural losses are likely to be incurred; and
  - No significant health effects are likely to occur. It should be noted that drinking water supply sourced from this dam is treated to potable standards prior to human consumption, further reducing the potential for human health effects.
- No significant or sensitive environmental features or important public facilities/utilities are present in the likely containment failure path.
- The water management system has been configured to ensure mine-affected water is contained within the mine water management system or released under controlled conditions to ensure there are no adverse impacts on downstream environmental values.

Based upon this preliminary assessment, the proposed mine water dams are considered 'low' consequence category structures and are not considered to be 'regulated structures' under the EP Act. A further detailed consequence category assessment will be conducted at the detailed design stage to confirm whether any of the mine water dams will be regulated dams under the EP Act.

Design criteria including the Design Storage Allowance (DSA), Extreme Storm Storage (ESS) and Mandatory Reporting Level (MRL) have been determined for the overall mine water management system and relevant mine water storages in accordance with the Manual requirements for "significant" hazard category dams (Table 13-3). This will ensure that the mine water management system complies with the regulated dam requirements in the event that any of the storages are assessed as regulated structures at the detailed design stage.

The dam sizings and performance against these design criteria have been determined by operational simulation modelling, as discussed in the following section.

13.5.4 Operational Modelling Method

An operational simulation model has been used to assess the project water balance across a range of climatic conditions over the life of the project. The model provides a dynamic simulation of water movement and stored water salinity within the proposed mine water management system over the life of the project.

The water balance model has been used to assess:

- Appropriate sizing of catch dams and water supply storage dams to collect and store mine-affected water with a low probability for uncontrolled discharges;
- Operational compliance of the mine water management system and individual storages with relevant regulatory requirements;
- Optimum utilisation of mine-affected water for mine water supply and minimising the volume of external raw water supply necessary for the project; and
- Frequency and volumes of any necessary controlled releases of mine-affected water to enable dewatering of the open cut pits following extended wet periods and avoid disruption to production.

The modelling was undertaken using GoldSim software. GoldSim is an operational simulation program used for modelling both natural and industrial water resource systems. It is industry recognised and has been used extensively throughout the Australian resource sector and is ideally suited for application to the project water balance.

Modelling Logic and Assumptions

The performance of the mine water management system and the requirement for external water supply, or controlled discharge of mine-affected water, will be dependent on numerous dynamic factors which will vary over the life of the mine. Consideration of static project stages in isolation over single wet or dry years will therefore not capture the full range of operational water management scenarios which may occur over the proposed mine life.

The operational performance of the mine water management system has therefore been simulated over the entire mine life. The operational mine life has been represented by detailed profiling of the incremental mine development stages and the mine production schedule, and has been assessed using 50 year historical climate sequences. This approach has enabled an assessment of a broad range of water supply, water demand and management scenario combinations which could potentially occur over the mine life.

The simulations are based on daily water balance iterations. The performance of the water management system was simulated for a total of 74 consecutive 50-year climate sequences from the 124 years of historical climate records available for the project site. The model simulation consequently involved a total of 3,700 mine operating years. The performance of the water management system has therefore been evaluated for all possible combinations of mine development timing and climate sequences on record. This includes the worst case combinations of mine development timing and high and low rainfall sequences.

For the purpose of the water balance model, a SILO Data Drill climate dataset was acquired from the Queensland Department of Science, Information Technology, Innovation and the Arts. The dataset comprised 124 years (1889 – 2013 inclusive) of rainfall and evaporation data interpolated from Bureau of Meteorology data. The dataset includes a maximum annual rainfall of 1,303 mm (in 2010) and a minimum annual rainfall of 134 mm (in 1902). The average annual rainfall is 616 mm. Annual pan evaporation for the project site ranges from 1,059 mm to 4,785 mm. Annual average pan evaporation is 3,216 and exceeds annual average rainfall by 2,600 mm.

Catchment runoff has been modelled using the Australian Water Balance Model (AWBM). The adopted AWBM parameters are provided in the *Water Management System Modelling Report* (Appendix K). Runoff modelling parameters have been selected based on experience and a review of comparable mining operations in Central Queensland and the Galilee Basin.

13.5.5 Water Management System Performance

Detailed results from the operational simulation modelling of the water management system are presented in the *Water Management System Modelling Report* (Appendix K). The representative long-term water balance for the project is represented by the overall median (i.e. 50thpercentile) of model results for the mine water management system. A summary of the results for three discrete years of the mine life during median climatic conditions is shown in Table 13-1.

These modelling results show that median water supply demands are variable over the life of the mine and are generally significantly greater than the amount of mine-affected water that will be generated by the project. This indicates a significant overall water deficit for the project and the need for a significant external water supply.

Table 13-1 Median Annual Water Balance

SOURCE	MEDIAN ANNUAL WATER BALANCE (MLpa)		
	Project Year 5	Project Year 15	Project Year 40
Water Supplies			
External Water Supply	5,431	7,762	3,529
TSF Return Water	1,291	2,462	1,034
Infrastructure Area Runoff	490	509	494
Underground Pit Dewatering	1,951	1,908	814
Open Cut Pit Dewatering	3,396	3,643	0
Stored Water Volume Change*	3,105	-119	817
Total Supplies	**15,664**	**16,165**	**6,688**
Water Demands			
CHPP	6,073	7,132	983
Power Station	2,975	2,975	1,488
Dust Suppression	1,800	1,810	1,539
Northern Underground	1,251	1,251	626
Southern Underground	626	0	0
Water Treatment Plant	222	198	87
Vehicle Washdown	110	95	30
Evaporation	2,607	2,704	1,935
Controlled Release	0	0	0
Total Demands	**15,664**	**16,165**	**6,688**

** Change in stored mine affected water volume over the year*

During extended rainfall periods the open cut pit will collect significant volumes of rainfall runoff and this will result in a net surplus of mine-affected water within the mine water management system. Following such events, in order to dewater the open cut pits and allow continuing production, it will be necessary for accumulated pit water to be discharged from site under controlled conditions. A detailed assessment of the controlled discharge of pit water is discussed below.

Mine Water Dam Sizing

Dam capacities and the DSA design criteria were initially derived using the 'Method of Deciles' approach described in the Manual. This method conservatively assumes that all rainfall and process inflows are stored with no losses. The model was then used to refine these initial capacities and DSA criteria using the 'Method of Operational Simulation for Performance Based Containment' as endorsed by the Manual. The operational simulation method uses predicted wet season increases in storage inventories to determine the DSA. Operational simulation includes a factor of safety in the form of a design simulation margin. The ESS and MRLs for each dam storage were derived in accordance with the Manual.

The mine water management system was designed to operate as an integrated containment system. The DSA and ESS design criteria for the integrated containment system may be shared across all mine water storages. Modelling results presented in Table 13-2 show that the mine water system will operate in compliance with the DSA and ESS requirements. Each individual mine-affected water dam will be operated such that the MRL will not be exceeded.

Table 13-2 Dam Capacities and Design Criteria

STORAGE DAM	CATCHMENT (ha)	CAPACITY (ML)	DSA (DECILES) (ML)	ESS (ML)
Open Cut Pit Water Dams				
Open Cut Pit Water Dam N1	Nil	340	N/A	N/A
Open Cut Pit Water Dam N2	Nil	340	N/A	N/A
Open Cut Pit Water Dam S1	Nil	340	N/A	N/A
Open Cut Pit Water Dam S2	Nil	340	N/A	N/A
Underground Pit Water Dams				
Northern Underground Pit Water Dam	Nil	55	N/A	N/A
Southern Underground Pit Water Dam	Nil	55	N/A	N/A
Mine Water Supply Storage Dams				
Mine Water Dam	Nil	1,600	N/A	N/A
Return Water Dam	Nil	850	N/A	N/A
Industrial Area Dam	Nil	1,350	N/A	N/A
Raw Water Dam	Nil	700	N/A	N/A
Infrastructure Area Catch Dams				
Northern Underground MIA Dam	21	50	145	42
CHPP Dam	39	95	269	79
Open Cut MIA Dam	60	145	414	121
Product Stockpile Dam	94	228	649	190
Power Station Dam	24	58	166	48
Raw Stockpile Dam	72	174	497	145
Southern Underground MIA Dam	15	36	104	30
Reject Stockpile Dam	14	34	97	28

STORAGE DAM	CATCHMENT (ha)	CAPACITY (ML)	DSA (DECILES) (ML)	ESS (ML)
Train Loadout Dam	23	55	159	46
Void				
Open Cut Pit (Project Year 30)	3,424	1,037,000	23,624	6,916
TOTAL	**3,786**	**1,043,845**	**26,122**	**7,647**

As discussed in the *Water Management System Modelling Report* (Appendix K), the DSA and ESS requirements calculated in accordance with the Method of Deciles are satisfied by the substantial storage capacity of the open cut pit.

Uncontrolled Discharge of Mine-Affected Water

The modelling results predict that the maximum inventory for all modelled years was 6,476 ML. This is less than the combined storage capacity of 6,845 ML for the proposed mine water management dams.

This demonstrates that there would be sufficient storage capacity for contained mine-affected water during the range of historical climate conditions over the life of the mine. A minimum of 369 ML spare storage capacity is available in the proposed dams even during the most extreme climate conditions experienced in 124 years of climate data.

The maximum predicted inventory of each individual dam is less than its assigned design capacity. This means that each dam could operate during any climate extremes within the range experienced over the previous 124 years without the need for uncontrolled discharges of mine water.

Table 13-3 shows the storage capacities and maximum modelled stored volume for all proposed dams.

Modelling indicates that no dams will overflow during the life of the mine. For the key mine water storages, modelling also indicates that for median conditions:

- There is a 46% chance that the Mine Water Dam will be less than 10% full at any point in time over the life of the mine;
- There is a 88% chance that the Return Water Dam will be less than 10% full at any point in time over the life of the mine; and
- There is a 99% chance that the Infrastructure Area Dam will be less than 10% full at any point in time over the life of the mine.

These modelling results indicate that the mine water management system has adequate capacity to contain mine-affected water generated by the project for the modelling scenarios. This demonstrates a very low probability of uncontrolled discharge of mine-affected water based upon long-term historical climate data.

Table 13-3 Dam Storage Capacities and Maximum Simulated Storage

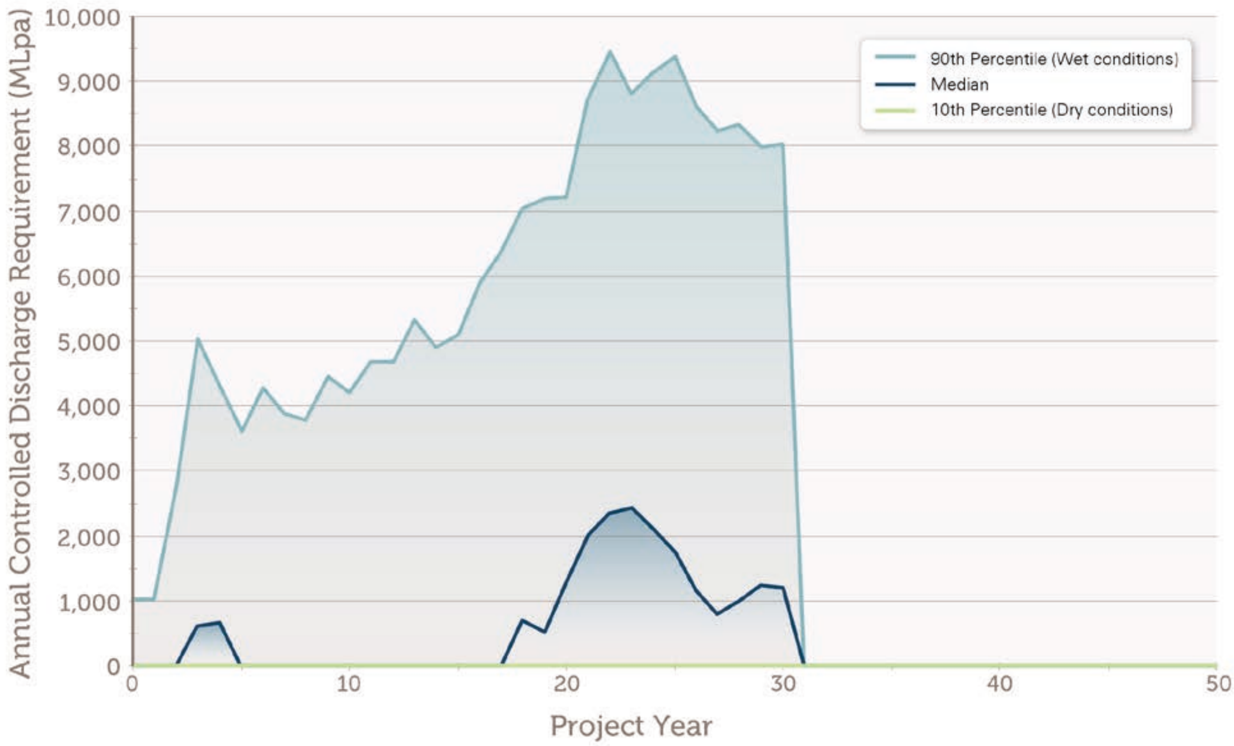
STORAGE DAM	DESIGN CAPACITY (ML)	MAXIMUM SIMULATED STORAGE VOLUME (ML)[1]
Open Cut Pit Water Dams		
Open Cut Pit Water Dam N 1	340	337
Open Cut Pit Water Dam N 2	340	337
Open Cut Pit Water Dam S 1	340	337
Open Cut Pit Water Dam S 2	340	337
Underground Pit Water Dams		
Northern Underground Pit Water Dam	55	54
Southern Underground Pit Water Dam	55	53
Mine Water Supply Storage Dams		
Mine Water Dam	1,600	1,594
Return Water Dam	850	816
Industrial Area Dam	1,350	1,318
Raw Water Dam	700	689
Infrastructure Area Catch Dams		
Northern Underground MIA Dam	50	15
CHPP Dam	95	50
Open Cut MIA Dam	145	114
Product Stockpile Dam	228	214
Power Station Dam	58	18
Raw Stockpile Dam	174	160
Southern Underground MIA Dam	36	9
Reject Stockpile Dam	34	8
Train Loadout Dam	55	16

1 Simulated volume reported as maximum modelled value over all simulations

Controlled Releases of Mine-Affected Water

As discussed in the previous section, modelling of the proposed mine water management system indicates that there would be no uncontrolled discharges of mine-affected water for the 124 years of climate data assessed. This means that the probability that an uncontrolled discharge will occur is less than once in 124 years (i.e. the average recurrence interval of a discharge event is greater than 124 years).

However, during extended wet periods, significant runoff volumes will accumulate in the open cut pit. To ensure that the open cut mine can continue to operate following these extended wet periods, the ability to discharge mine-affected water under controlled conditions is required. The water management system has therefore been designed to allow for the controlled release of stored pit water from the Mine Water Dam to the Belyando River catchment. Graph 13-1 shows the probability distribution for average annual discharge requirements over the 50 year mine life.



Graph 13-1 Probability Distribution for Annual Controlled Discharge Requirements

The modelling results indicate that under median conditions the average annual discharge requirement is approximately 400 MLpa, with a peak annual discharge requirement of 2,438 MLpa. The project is predicted to operate with nil discharge during 70% of project years.

The storage capacity of the proposed Mine Water Dam is 1,600 ML. Based on these modelling results, on average, less than 25% of the Mine Water Dam capacity would need to be discharged under controlled conditions per year. In the year in which the maximum discharge requirement of 2,438 MLpa occurs under median conditions, the equivalent of less than two discharges of the total Mine Water Dam storage capacity would be required.

Any controlled discharges from the Mine Water Dam would be conducted in accordance with the EHP's Model Mining Conditions. These conditions are designed to prevent any adverse impacts on downstream environmental values.

Section 24 – Environmental Management (Attachment 24-4) provides details of site-specific discharge conditions for the project. The proposed discharge conditions provide the following:

- Locations for:
  - Nominated point of release from the Mine Water Dam;
  - The receiving waters of the Belyando River; and
  - Upstream and downstream monitoring locations.
- Mine-affected water release limits including EC, pH and turbidity. In accordance with the model EA discharge conditions, turbidity (by instantaneous measurement) has been nominated as a surrogate for suspended sediments (by laboratory analysis) due to the remoteness of the project site. The proposed release limits have been determined as follows:
  - EC – flow dependent criteria based upon long-term daily flow data for the downstream receiving water monitoring location;
  - pH – as per the EHP Model Mining Conditions; and
  - Turbidity – as per the EHP Model Mining Conditions, this will be derived based on measured dam water data.
- Release trigger levels for a range of potential contaminants and receiving water trigger levels for key water quality parameters (pH, EC, turbidity and sulphate). In the event of an exceedance of the proposed levels, a tiered investigation of the water release event will be initiated. The proposed trigger levels are as per the model EA discharge conditions.
- Monitoring commitments for controlled releases, in accordance with the model EA discharge conditions.

The maximum modelled salinity of water in the Mine Water Dam over the life of the mine is approximately 3,200 µS/cm. Salinity is predominantly contributed by groundwater inflows to the underground workings and open cut pit. The salinity of pit water stored in the Mine Water Dam increases during dry weather conditions when there is limited or nil surface runoff contributing to open cut pit water to dilute the groundwater salinity.

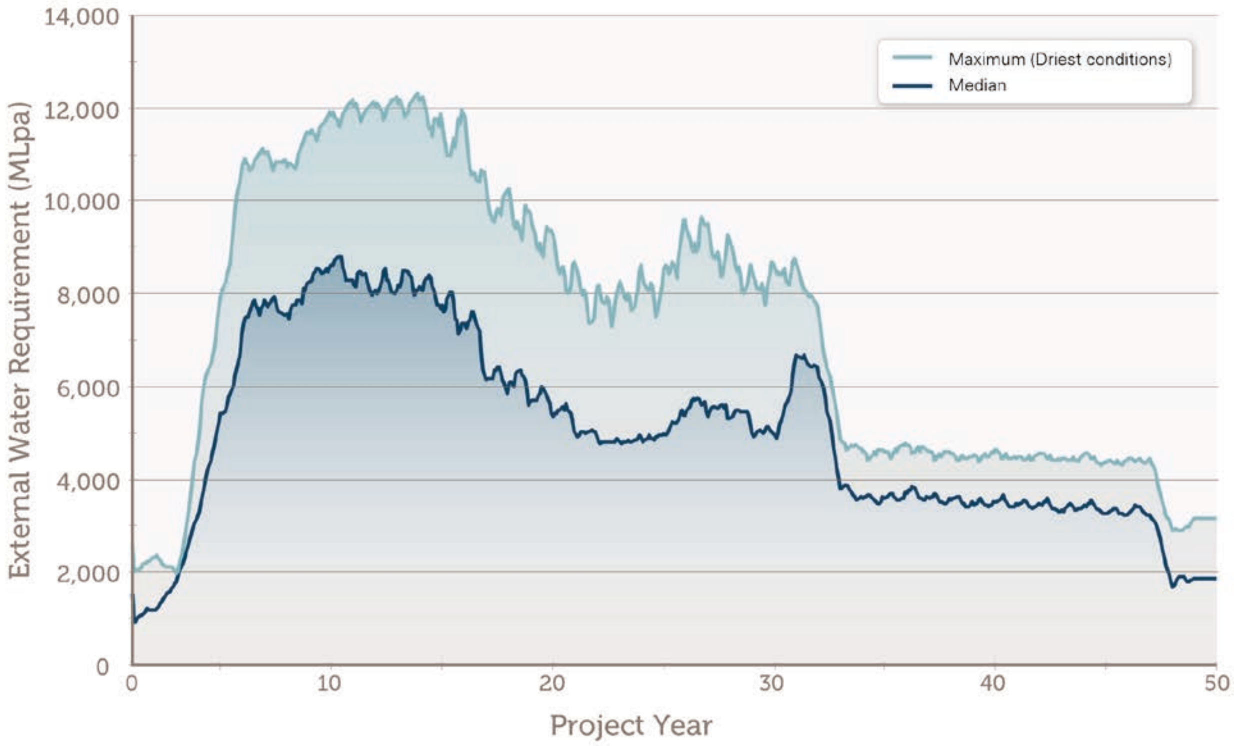
However, controlled discharges will only be required during and following extreme wet periods when the proportion of fresh rainfall runoff in open cut pit water and the Mine Water Dam storage is higher and groundwater salinity is diluted. The maximum modelled salinity of water in the Mine Water Dam during controlled releases is less than 1,500 µS/cm.

An assessment of the potential impacts of controlled release of mine-affected water on downstream aquatic ecology is included in Section 10 – Aquatic Ecology (Subsection 10.6.4).

Water Supply Reliability

External water will be required to supply water demands which require high quality water including supply to underground mines, the water treatment plant, vehicle washdown and the power station. Modelling also shows that additional external water supply is required in dry periods when the volume of mine-affected water stored on site is insufficient to meet project demands.

Graph 13-2 shows the modelled annual external water supply requirement. The mine water management system is predicted to have a water deficit over the life of the mine. Modelling shows that the annual external water requirement will range from approximately 903 to 12,300 MLpa over the life of the mine. Demand for external water supply peaks in between Project Years 8 and 16, when mine production is at its greatest.



Graph 13-2 Annual External Water Supply Requirement

The proponent is proposing to secure an annual external water supply of up to 12,500 ML for the project to ensure continued operation of the mine over the 50 year mine life with negligible risk that operations would cease in the driest climate scenario due to lack of water supply.

There are a number of parties currently developing water supply options for the Galilee Basin coal mines. The current preferred water supply option would be to gain an allocation from a piped water supply from one of two schemes being proposed to harvest water from the Cape River or the Belyando/Suttor River system. The latter scheme has the potential to be supplemented by a connection to the Burdekin Falls Dam. Any future water supply scheme would be developed by others and would be subject to separate environmental impact assessment and approvals.

13.5.6 Monitoring

Water management system monitoring for the project will include quarterly monitoring of water levels and quality in mine water storage dams including the Return Water Dam, Mine Water Dam and intermediate pit water dams, and the Industrial Area Dam and associated infrastructure area catch dams. Parameters to be included in the monitoring program include pH and EC and will include annual monitoring of a comprehensive suite of water quality parameters, including metals and metalloids.

Any controlled releases of mine-affected water will be monitored in accordance with the EHP's model EA conditions relating to the release of mine-affected water. These conditions require monitoring of the water released from the site, as well as the receiving waters.

The site water balance including water transfers, consumption and dam storage volumes will be monitored monthly. The water management system will be monitored and managed in accordance with a Site Water Management Plan. The Site Water Management Plan is discussed in detail in Section 24 – Environmental Management. The site water balance will be reviewed annually and will trigger modifications to the water management system, where necessary, to ensure the optimum operation of the system.

Sediment control structures will be managed in accordance with an ESCP. The ESCP will include an inspection plan for sediment control structures to ensure they are maintained and remain effective.

13.5.7 Climate Change

Climate change predictions are discussed in Section 14 – Climate. It is predicted that the project site could experience a long-term reduction of 1-7% in rainfall and increased evaporation. This is countered by a greater number of extreme rainfall events. The effects of these climate changes on the proposed water management system would be a potential minor reduction in the long-term accumulated rainfall runoff within the system, but an increase in short-term storm events. Due to the robust nature and design of the proposed water management system, the predicted changes in rainfall intensity and frequency will not have a material impact on the effective operation of the water management system. In particular, any increase in runoff from higher intensity storm events would be accommodated by the conservatively sized catch dams (Table 13-3). These dams have been conservatively sized to contain 100% runoff from the 72 hour 20 year ARI storm event. Any minor increase in external water demand due to reduced rainfall associated with climate change could be managed by securing additional external water supply.

13.6 SURFACE WATER IMPACTS

The key potential impacts of the project on surface water will be:

- Sedimentation of downstream waterways during construction and operations due to erosion from disturbed areas on the project site and increased sediment loads in site drainage water.
- Mining disturbance and mine site drainage changing catchment areas, potentially resulting in downstream catchment yield impacts.
- Mining disturbance and mine site drainage altering downstream drainage and potentially resulting in:
  - Changes to flood behaviour including flow paths, flood inundations areas and flow velocities; and
  - Geomorphic impacts on watercourses and drainage lines including impacts on channel bed and bank stability.
- Subsidence of the ground surface and surface drainage features as a result of underground longwall mining, potentially resulting in:
  - Surface drainage impacts including ponding of runoff in subsidence depressions; and
  - Geomorphic impacts on subsided drainage lines including impacts on channel bed and bank stability.
- Controlled discharge of mine-affected water resulting in downstream water quality impacts on environmental values and water users.
- Impacts of the final landform and final void on surface drainage.

These impacts and proposed management and mitigation measures are described in the following sections.

13.6.1 Sedimentation Control

Runoff from areas disturbed by construction and mining activities may contain elevated levels of suspended sediment. An ESCP will be developed prior to commencement of construction to address erosion and the control of suspended sediment in drainage from these areas.

Runoff from disturbed areas will be captured in collection drains and directed through sediment traps and sediment dams for control of suspended sediment prior to discharge from site. Sediment collected in sediment dams will be excavated at regular intervals and disposed of in the overburden emplacement areas. Diversion drains will be installed to divert overland flow from upstream areas around disturbed areas.

All works will be designed and constructed in accordance with an ESCP.

13.6.2 Catchment Impacts

The existing catchment setting is described in Section 13.2. The project lies predominantly within the Tomahawk Creek and North Creek catchments, with minor areas of the project site draining to the Carmichael River and Lake Buchanan catchments.

The development of the mine and its associated water management system will result in the capture and diversion of runoff. During project operations, this will include runoff from contained catchments in the open cut mine and mine infrastructure area. Post mine closure, runoff to the final void catchment will be retained on site. This will result in a reduction in the total catchment runoff from the project site compared to pre mining conditions.

The construction of the permanent highwall drains will result in approximately 394 ha of the Tomahawk Creek catchment being diverted into the North Creek catchment. This will result in a decrease in catchment runoff to Tomahawk Creek, and a simultaneous increase in the runoff to North Creek. This will partially offset the loss of contributing catchment to the North Creek catchment area due to mining activities and the final void.

The highwall drains will also intersect a minor area of the Carmichael River catchment (2 ha). The project will not result in any changes to the Lake Buchanan catchment.

Over the life of the project, a maximum catchment area of 4,226 ha will be contained on the project site at Project Year 30. This contained catchment area corresponds to a maximum reduction in catchment area of approximately 2% for the Tomahawk Creek catchment and 7% for the North Creek catchment. Post mining, the contained catchment of the final landform will reduce to 2% for both the Tomahawk and North Creek catchments, respectively. The post mining contained catchment corresponds to 0.09% of the Belyando River catchment and 0.03% of the Burdekin Falls Dam catchment. This represents a negligible proportion of the overall receiving catchment areas.

No downstream water use has been identified in the Tomahawk or North Creek catchments that would be significantly affected by these relatively minor reductions in catchment area. The impacts of changes in catchment yields at grazing properties downstream of the project site will therefore be minimal.

13.6.3 Drainage Impacts

Hydraulic modelling of the site drainage system has been conducted to determine the potential downstream drainage impacts of the project (*Open Cut Mine Drainage Report,* Appendix J).

Hydraulic modelling results for the mine drainage system were assessed for the 1 in 2 and 1 in 50 Annual Exceedance Probability (AEP) flood events in order to quantify surface water impacts on downstream properties and stream geomorphology. Predicted impacts on peak flood levels, flow velocities, bed shear stress and stream power are summarised in the following sections.

Flood Impacts and Mitigation Measures

Figures 13-10 and 13-11 show the flood afflux for the 1 in 2 and 1 in 50 AEP flood events during the operations phase, respectively. Existing and post mine flood afflux plans for the 1 in 2, 1 in 50 and 1 in 1,000 AEP design floods are provided in the *Open Cut Mine Drainage Report* (Appendix J). The flood afflux has been determined by subtracting the pre-mine flood levels from the operations phase levels such that a positive afflux represents an increase in flood levels and conversely a negative afflux represents a reduction in flood level.

Peak 1 in 2 AEP flood levels are predicted to increase by between 0.05 and 0.15m in some drainage features downstream of the eastern project site boundary. Peak 1 in 50 AEP flood levels at the northern boundary of the project site downstream of the northern highwall drain are predicted to increase by between 0.3m and 0.5m. The increase is localised and dissipates less than 200 m north of the project site boundary.

Reductions in flood levels are also predicted in several minor drainage features downstream of the project site boundary. This is mainly due to the redistribution of flow that will occur due to the project, resulting in some drainage features carrying more water while flow in others is reduced.

The predicted changes in flood levels and distribution will not impact on any structures or property, and in most cases will not be discernible when compared to existing conditions due to the wide shallow nature of the flow paths. The grazing land use on the downstream properties is also not sensitive to these minor and localised changes in flood levels and flow distribution.

No significant flood impacts are therefore predicted.

Geomorphic Impacts and Mitigation Measures

An assessment of the drainage features that will be impacted by the project activities has been completed and the locations at which works may be required to mitigate any potential impacts have been identified.

Eastern Boundary of Project Site

Figures 13-12 and 13-13 show the predicted changes in flow velocities for the 1 in 2 and 1 in 50 AEP flood events during the operations phase, respectively. Minor increases in 1 in 2 AEP flow velocities are predicted at and downstream of the eastern boundary of the project site. The predicted increases are typically less than 0.1 m/s. Existing peak 1 in 2 AEP flow velocities in this area are low and typically between 0.25 m/s and 0.5 m/s. During the larger 1 in 50 AEP flood, flow velocities in drainage features downstream of the eastern boundary of the project site are predicted to increase by up to 0.1 m/s, with some localised increases of up to 0.2 m/s, particularly adjacent to the northern topsoil stockpile area and at the outlets of the railway embankment culverts. There is little change to shear stress or stream power downstream of the eastern boundary of the project site. This is due to the shallow, low velocity nature of flooding in this area and the relative small changes to flow behaviour predicted.

There are also a number of drainage features, both within the project site boundary and downstream of the eastern boundary which are predicted to experience reduced peak flow velocities of up 1 to 2 m/s due to the redistribution of flows.

Overall, the floodplain and drainage features downstream of the eastern boundary of the project site are characterised by low depth and low velocity flows, typical of low energy flowpaths. The project is not predicted to have significant impacts on these drainage features, based upon the minor predicted changes in velocities, flood depths, bed shear stresses and stream power. No management or mitigation measures are proposed for these drainage features. However, If necessary, a small earth bund will be constructed at the northern end of the topsoil stockpile area to prevent erosion of any stockpiled topsoil in this area during flooding. These minor bunds are not floodplain management measures or levees and there are no significant environmental, safety or wider economic consequences associated with a potential failure of these bunds. On this basis these bunds are not considered regulated structures.

The culverts beneath the railway and road embankment, as shown on Figure 13-4, will be subject to detailed design, to be undertaken at a later stage. Detailed design of these culverts will include selection of appropriate culvert headwall and apron structures (including concrete or rock gabion erosion protection and energy dissipation areas) to minimise erosion at culvert inlets and outlets. Detailed design of the railway embankment culverts will also include works downstream of culvert outlets to mitigate the concentration of flow by returning culvert discharges to a wide shallow flowpath before they pass across the eastern boundary of the project site.

Northern Drainage Corridor

Localised increases in peak flow velocity are predicted along the project site boundary downstream of the outlet of the northern highwall drain. Existing peak 1 in 2 AEP velocities within the drainage feature channels in this area are typically greater than 1.5 m/s with increases of 0.1 m/s to 0.3 m/s predicted for the 1 in 2 AEP flow event.

Increases of up to 0.4 m/s are predicted in this area for the larger 1 in 50 AEP flow event. Overbank velocities are significantly less than those in the channels.

A limited area along and immediately downstream of the project site boundary downstream of the outlet of the northern highwall drain will be exposed to increased flood levels, flow velocities, bed shear stresses and stream power. It is of note that this area experiences reasonably high velocities, bed shears and stream power under existing conditions, and existing erosion is evident downstream of this area.

It is possible that this area will experience increased erosion in both channels and overbank areas. Erosion protection and energy dissipation measures for the drainage features downstream of the northern highwall drain will be considered during detailed design. Measures to be considered may include, but are not limited to:

- Rock erosion protection around areas of high velocity and bed shear stress;
- Energy dissipation structures including flow spreaders; and
- Geofabric protection and planting and revegetation of overbank and floodplain areas.

Southern Drainage Corridor

In the southern drainage corridor downstream of the southern highwall drain, peak flow velocities are predicted to increase in localised areas within the subsided area above the Southern Underground mine (Figures 13-12 and 13-13). However, existing peak flow velocities are typically low in this area and increased velocities are limited to the subsided area.

Geomorphological impacts due to subsidence above the Southern Underground mine will be limited to areas within the project site boundary. Hydraulic modelling results indicate that the drainage features within the subsidence zone could potentially experience erosion over the life of the project. This area will be monitored for erosion after flow events and erosion control measures will be installed, if necessary.

Climate Change

As discussed in Section 13.5.7, climate change predictions indicate that the project site could experience a greater number of extreme events including cyclones and associated extreme rainfall events. The flood modelling results indicate that the project will not result in any significant impacts due to flood inundation. The site drainage system is also designed with capacity to convey the PMF. Given the robust design of the site drainage system, the conservatism in the flood modelling assumptions and the low sensitivity of the downstream area to flood impacts, any increase in extreme rainfall events as a result of climate change is not likely to give rise to any significant additional flood impacts.

13.6.4 Subsidence Impacts

Subsidence Impacts on Surface Drainage

Subsidence may lead to the ponding of water in localised shallow surface depressions and loss of catchment yield.

Subsidence ponding will be mitigated by the installation of minor remedial drainage earthworks to re-establish free drainage as discussed in Section 13.4.1. The indicative locations of minor remedial drainage earthworks are shown on Figure 13-8.

With the installation of minor remedial drainage earthworks and the re-instatement of free drainage, there will be no significant residual ponding caused by mine subsidence and no loss in catchment yield. Works would be conducted in accordance with the *Draft Subsidence Management Plan* (Appendix B) and the ESCP.

Subsidence Impacts on Drainage Features

Subsidence above the Northern Underground mine will affect minor rock gullies and may result in localised changes to gully bed elevations. The changes in bed elevation will result in localised flow velocity changes. Flow velocities will increase as drainage flows into subsided areas and decrease across the downstream extent of the subsided area. In high sediment load drainage systems, this can result in erosion (e.g. headcuts) and sedimentation across the subsidence area. However, the gullies at the project site are rock controlled channels with limited bed sands due to the naturally high velocities experienced during ephemeral flows. Consequently, the potential for subsidence induced channel instability in these areas is negligible.

Nonetheless, subsidence of drainage gullies will be monitored to identify any geomorphic impacts. Remedial stabilisation will be undertaken where necessary. All monitoring and remediation will be undertaken in accordance with a Subsidence Management Plan. A draft Subsidence Management Plan is included in Appendix B.

13.6.5 Controlled Releases of Mine-Affected Water

As discussed in Section 13.5.5, any release of mine-affected water from the project site will be conducted in accordance with the EHP's model EA discharge conditions.

The conditions include discharge water volume and quality limits that are specifically designed to protect downstream water quality and environmental values. These conditions also address potential cumulative impacts by taking into account the assimilative capacity of the receiving environment.

13.6.6 Post Mining Impacts

Final Landform Drainage

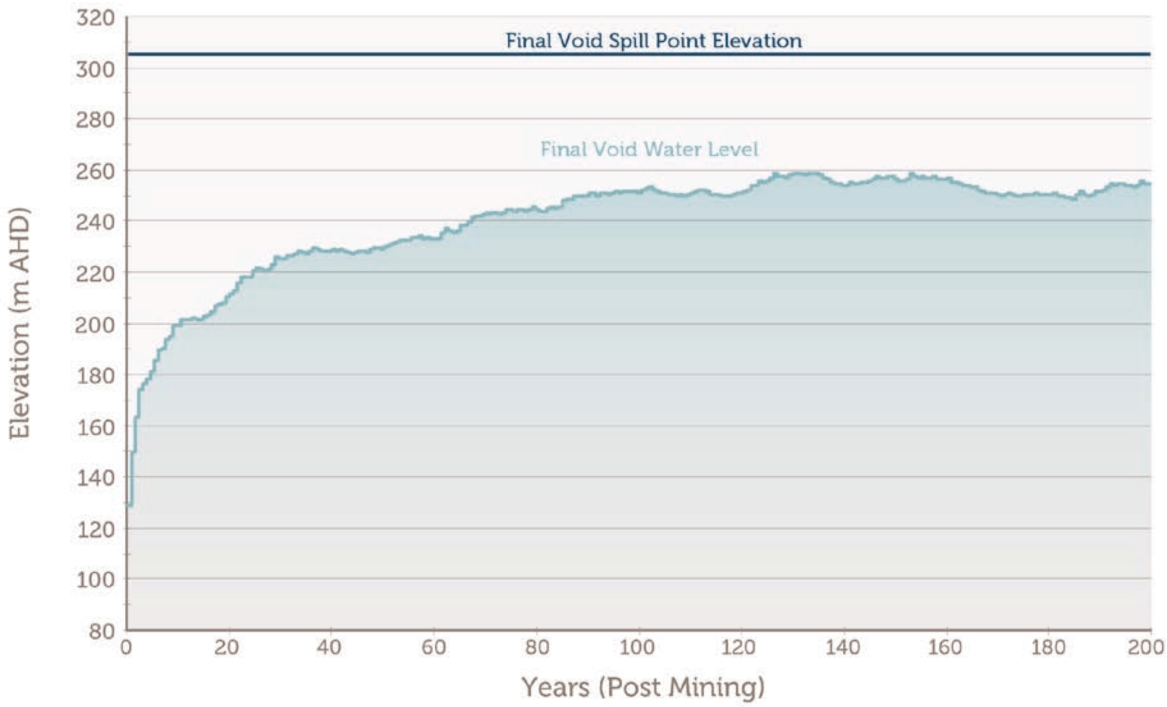
The final landform is shown in Figure 13-7. As discussed previously, the highwall drains and the northern and southern drainage corridors will remain in the final landform. Modelling of the PMF on the final landform (*Open Cut Mine Drainage Report,* Appendix J) confirms that the highwall drains and drainage corridors can convey the PMF and the final void has PMF flood immunity. The proposed final landform therefore has suitable drainage characteristics for the post-mining phase.

Final Void

Modelling of the final void water storage was completed to assess the likely final void water levels following mine closure (*Water Management System Modelling Report*, Appendix K). The final void modelling takes into account rainfall runoff from the final void catchment, modelled groundwater inflows to the void and evaporative losses from the surface of the final void lake. The dynamic response of groundwater inflow to the water elevation in the final void has been derived from groundwater modelling (*Groundwater Report*, Appendix I).

The model was simulated using 124 years of historical rainfall data that was resampled to assess long-term post closure void behaviour over a 200 year period.

The model results are shown in Graph 13-3. The results indicate that the final void lake is likely to reach a quasi-equilibrium level in the long-term, less than 200 years after mine closure. This occurs when the evaporative losses from the surface of the void lake match the groundwater inflows and surface runoff inputs.



Graph 13-3 Final Void Water Level

The long-term void lake water level fluctuates in the range of 249 to 260 m AHD with an average elevation of 255 m AHD. The average final void lake water level is 50 m below the final void spill point elevation of 305 m AHD. The salinity of the final void water storage is likely to increase over time due to the evaporative losses from the surface of the lake. However, overflow from the final void to downstream drainage is extremely unlikely based on the void lake modelling results.

The influence of the long-term void lake water level on the post mining groundwater regime is discussed in Section 12 – Groundwater.

FIGURES

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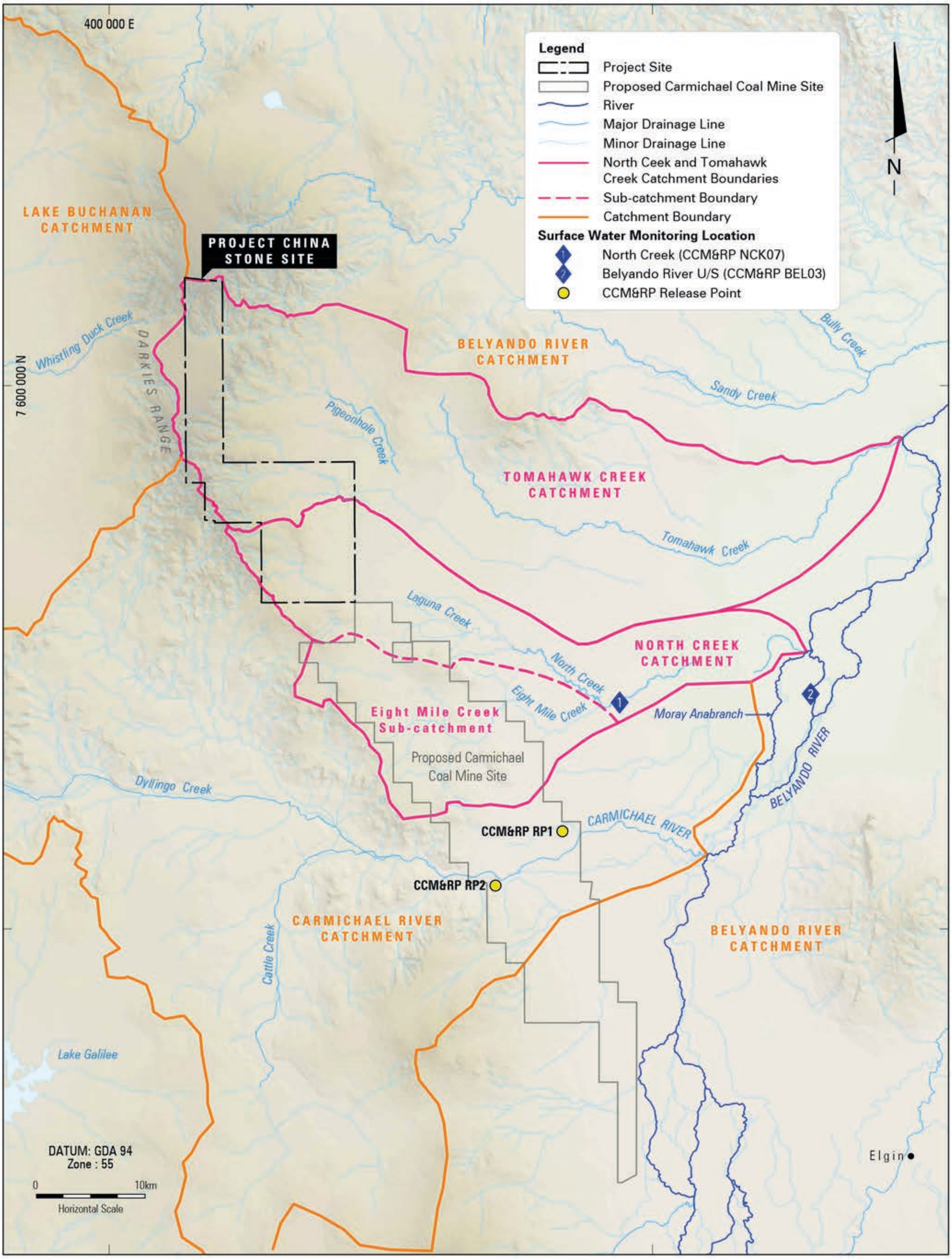
Regional Catchment Setting

FIGURE 13-1



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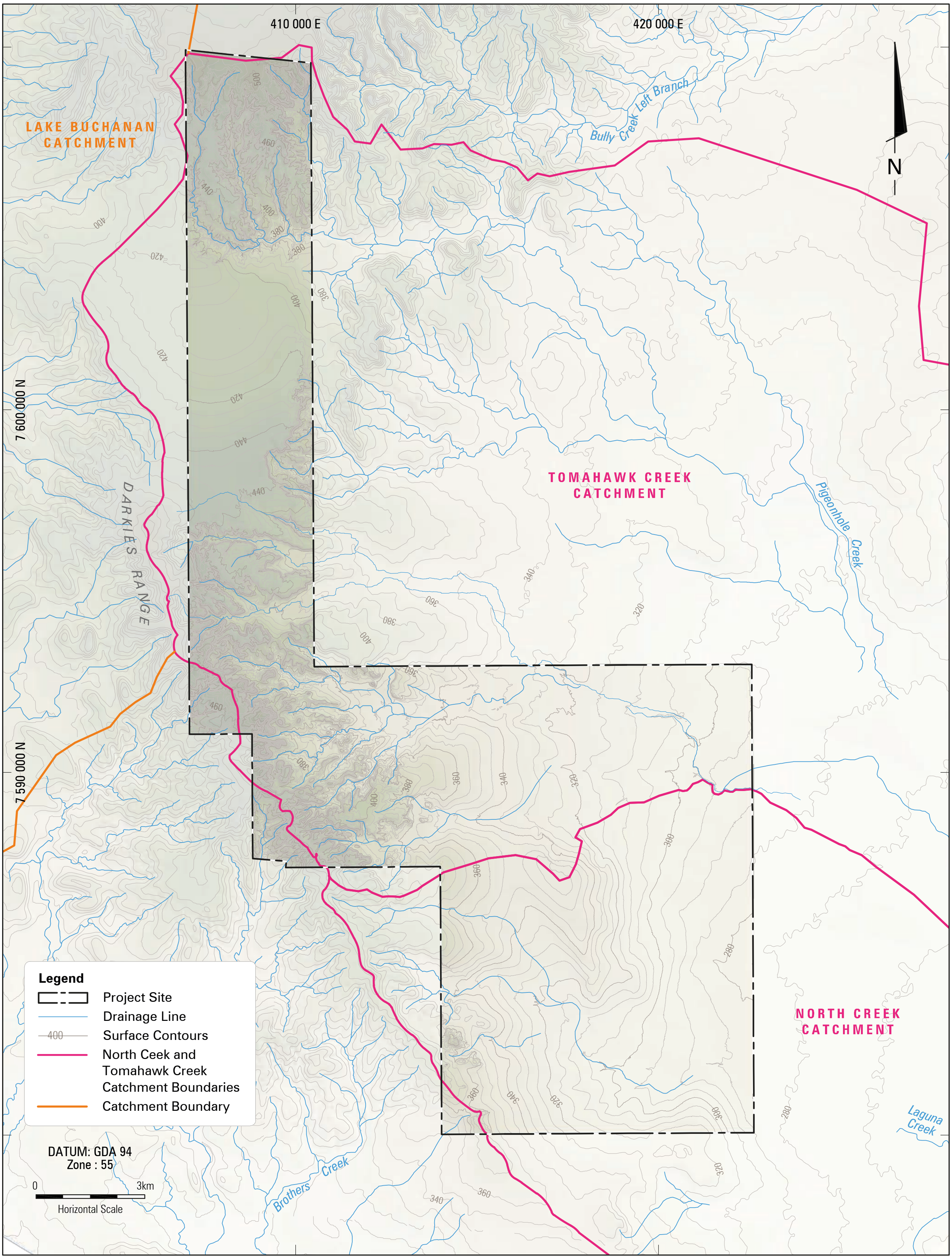
Local Catchment Setting

FIGURE 13-2



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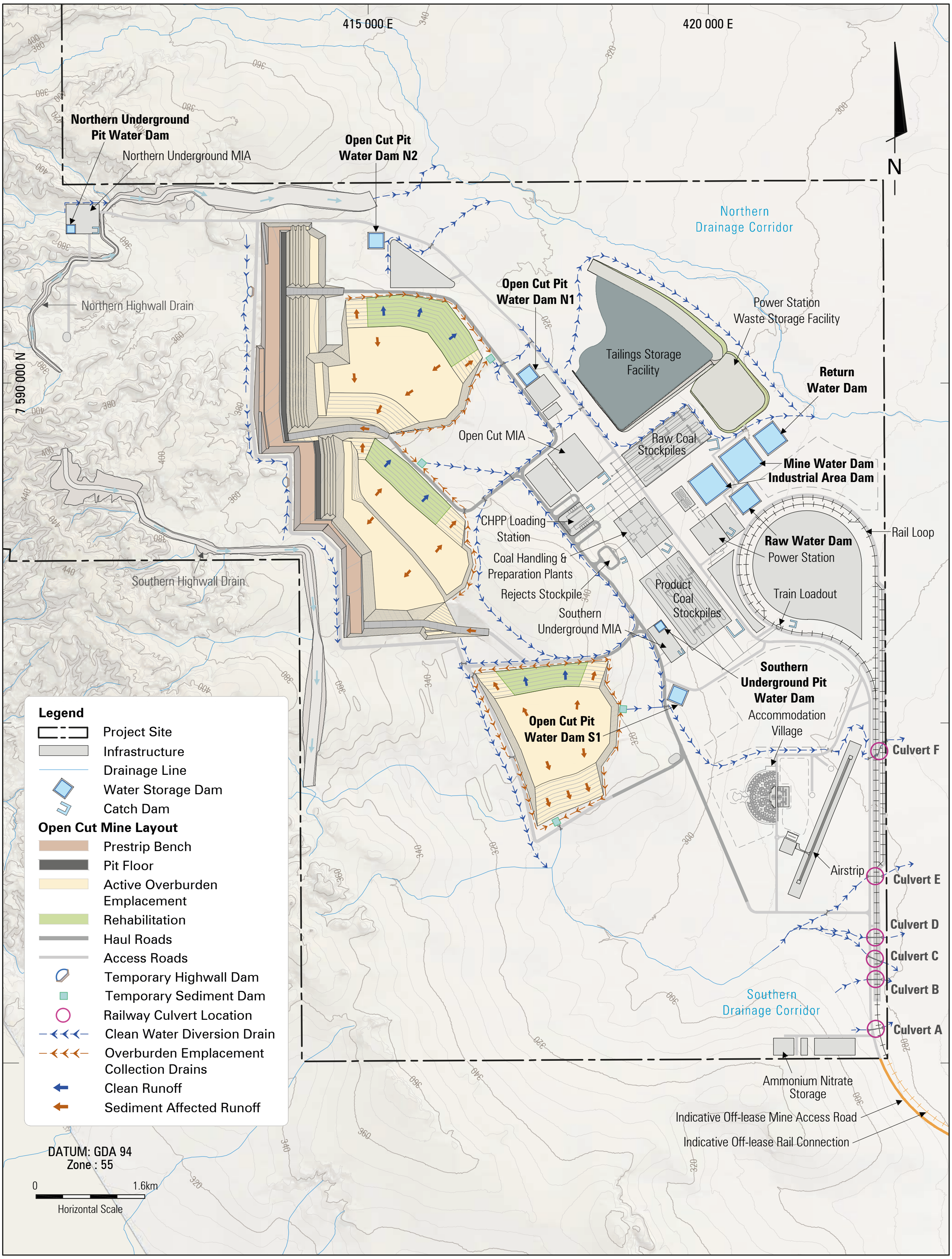
Existing Site Drainage

FIGURE 13-3



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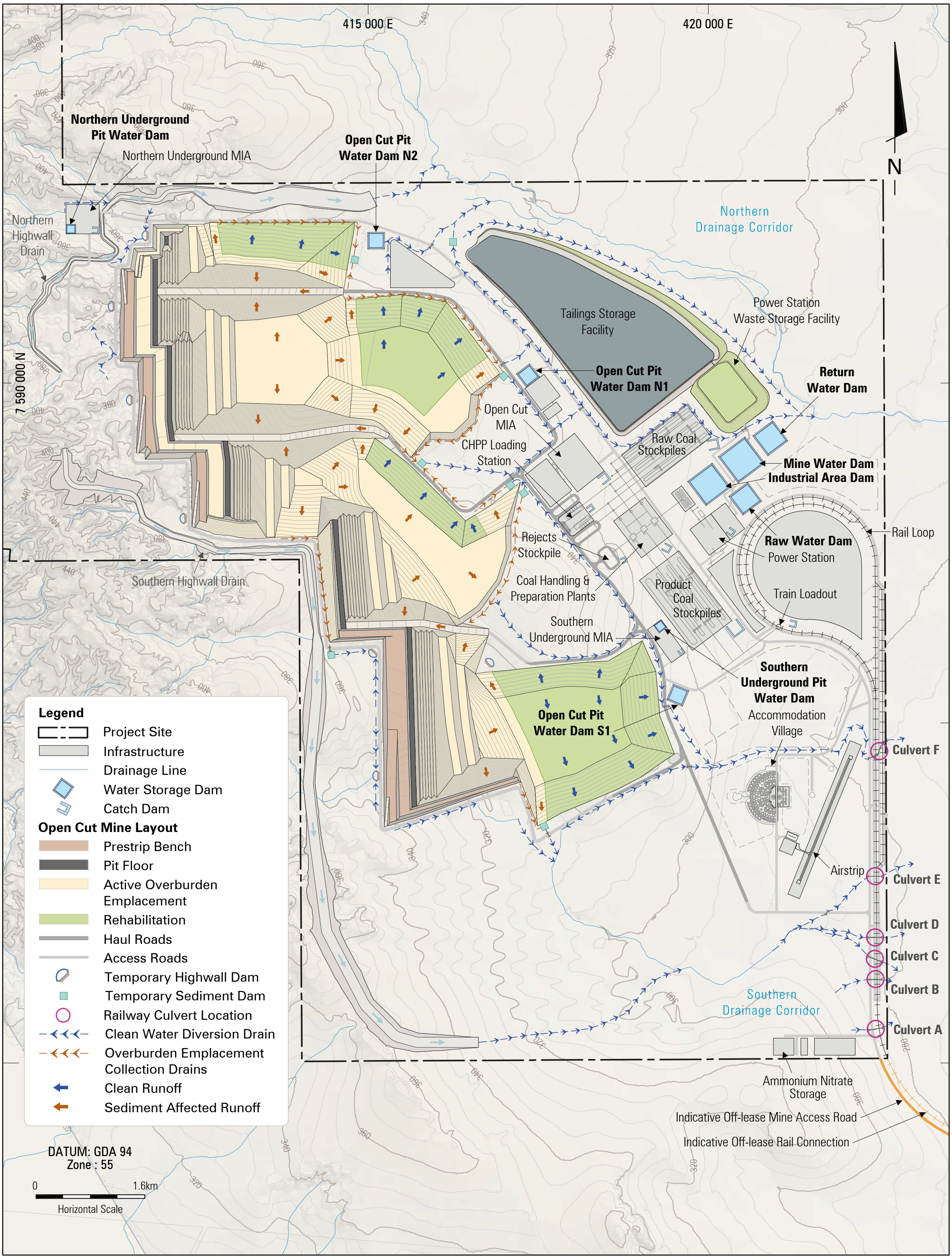
Conceptual Site Drainage - Project Year 5

FIGURE 13-4



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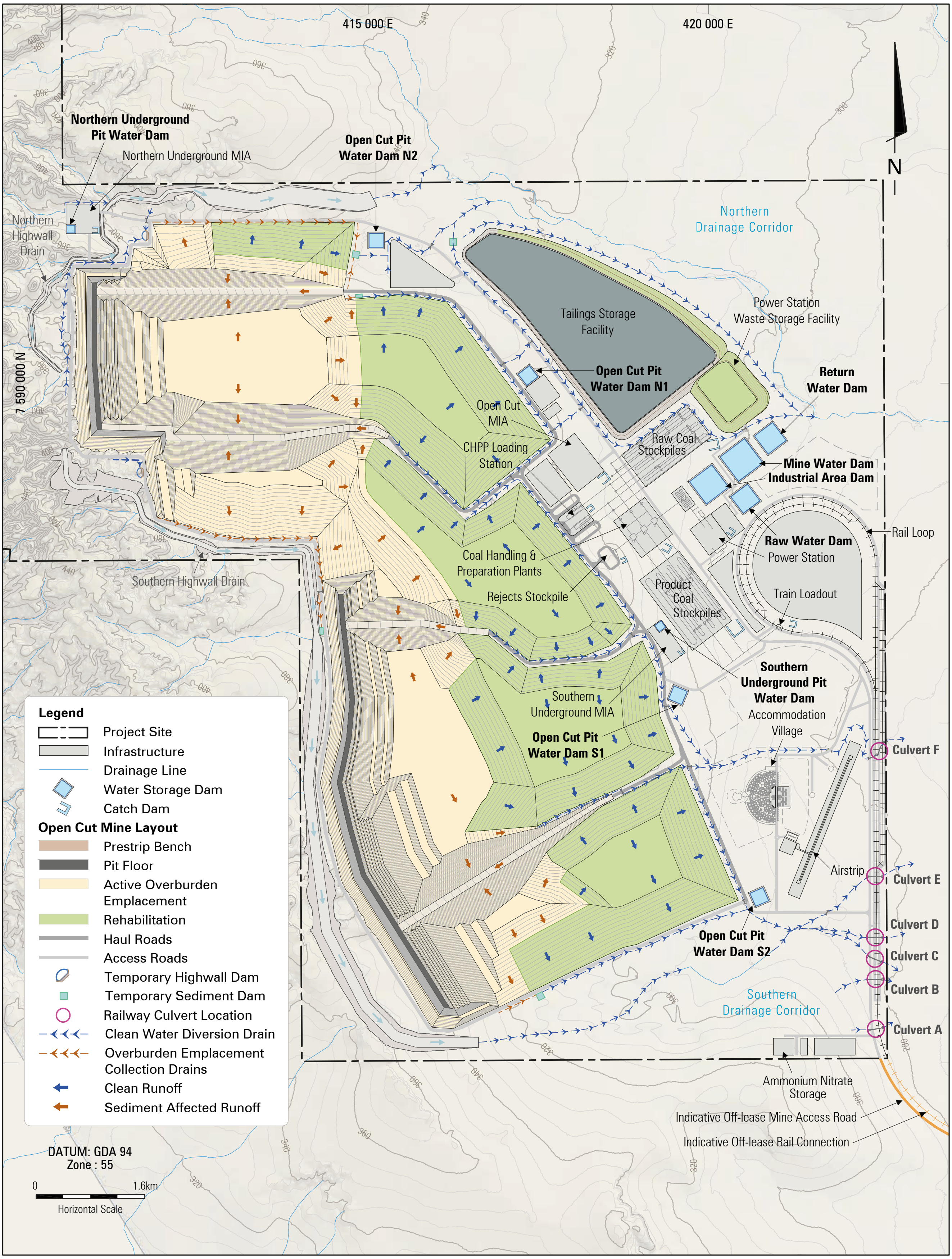
Conceptual Site Drainage - Project Year 15

FIGURE 13-5



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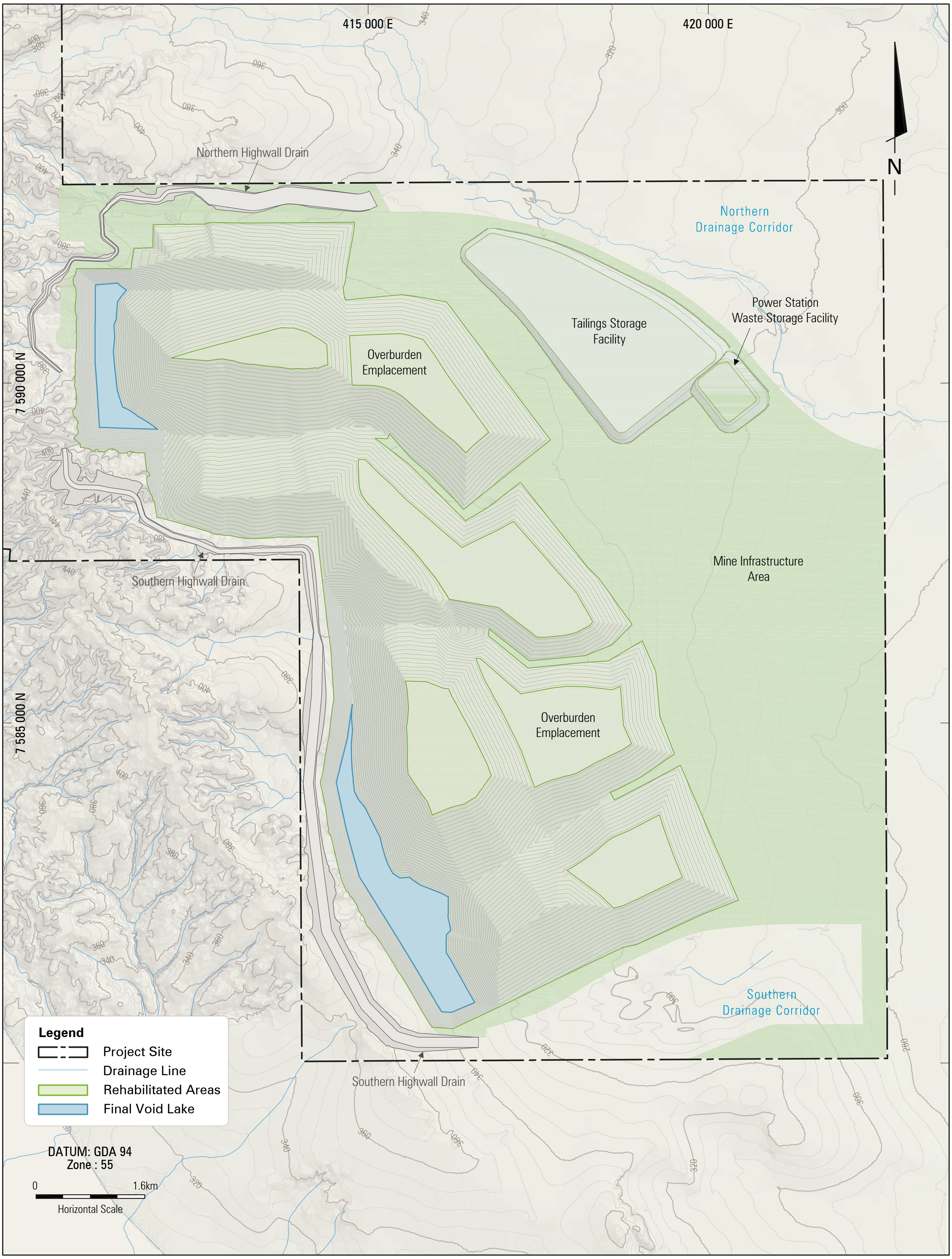
Conceptual Site Drainage - Project Year 30

FIGURE 13-6



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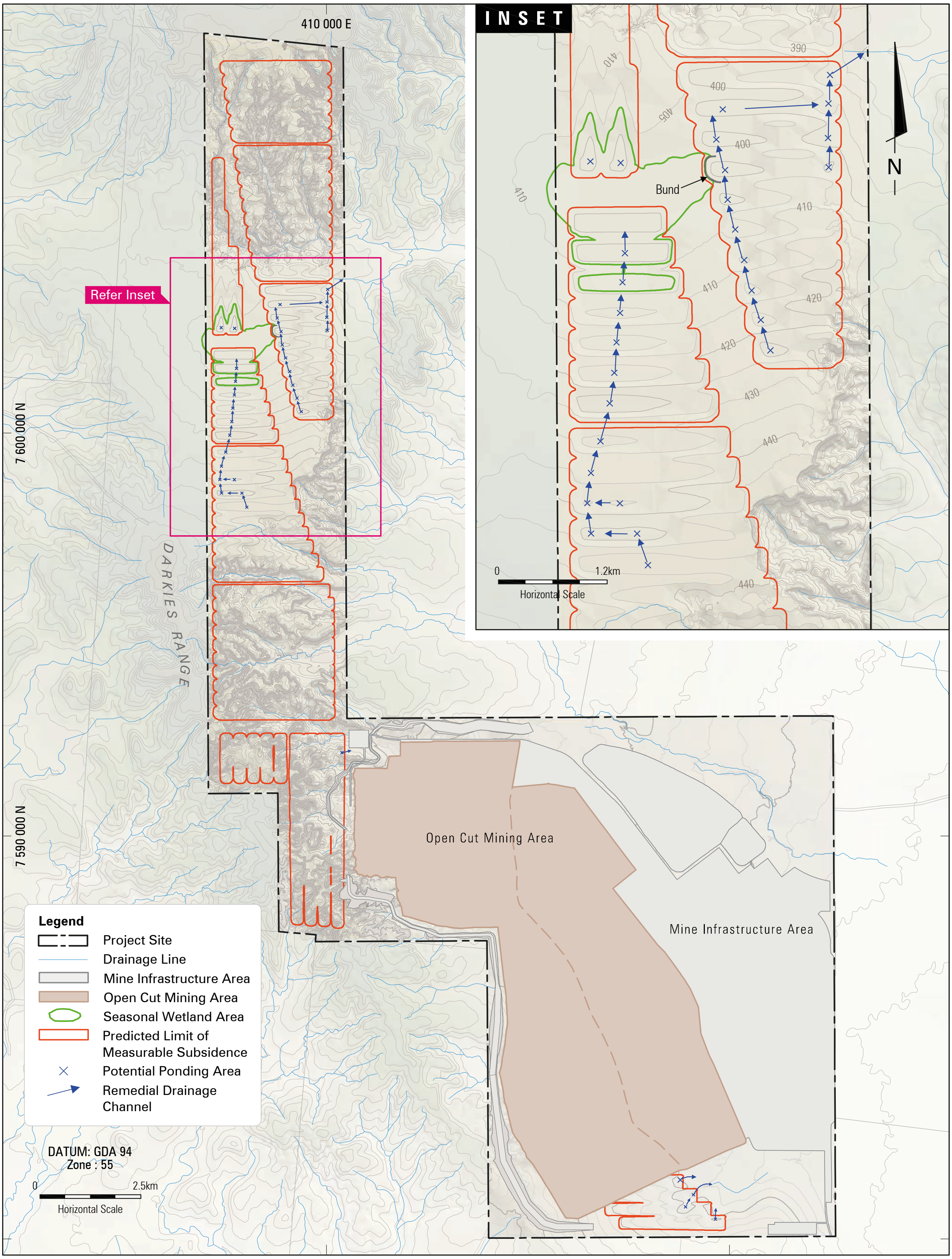
Conceptual Site Drainage - Final Landform

FIGURE 13-7



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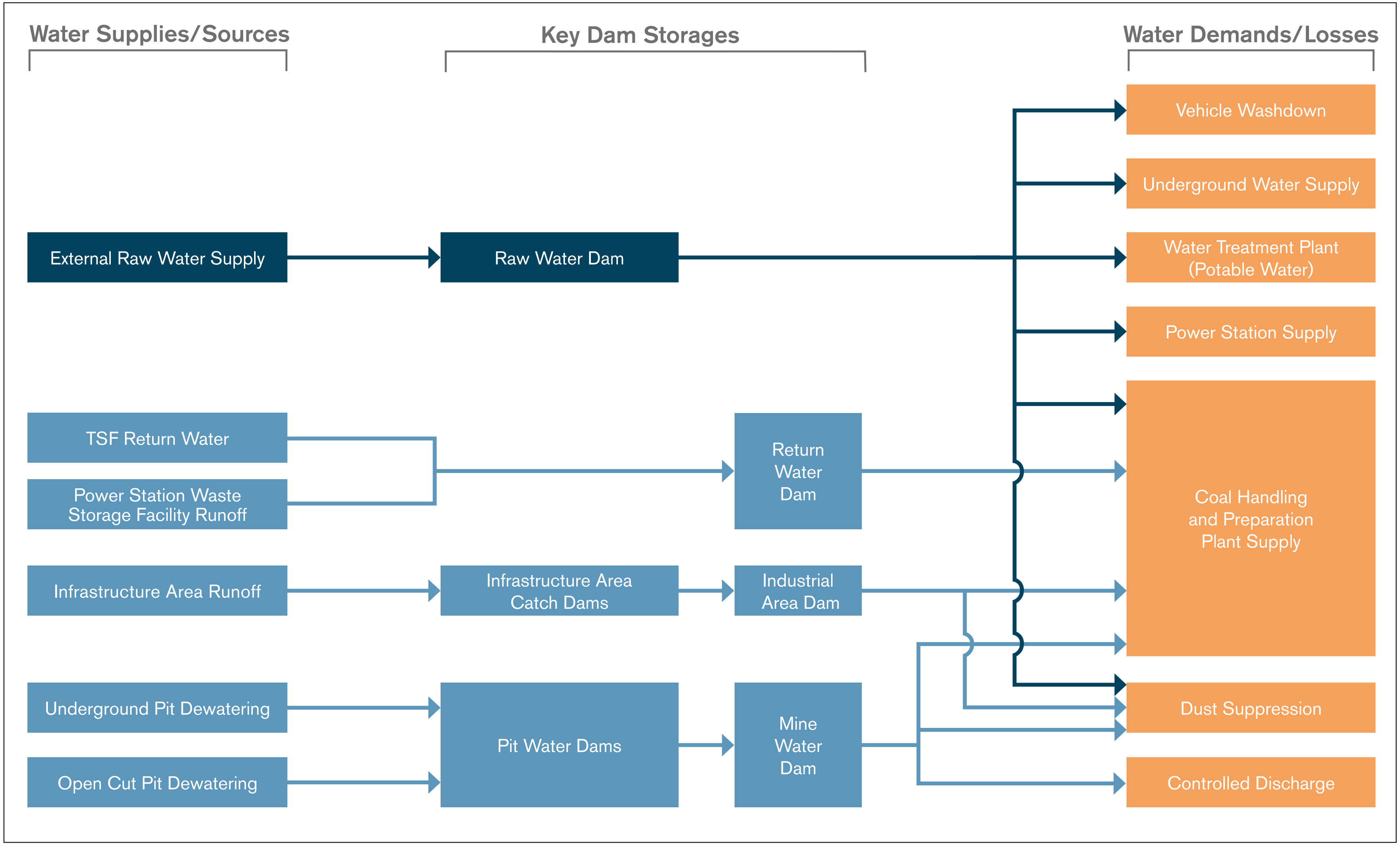
Subsidence Ponding and Remedial Drainage

FIGURE 13-8



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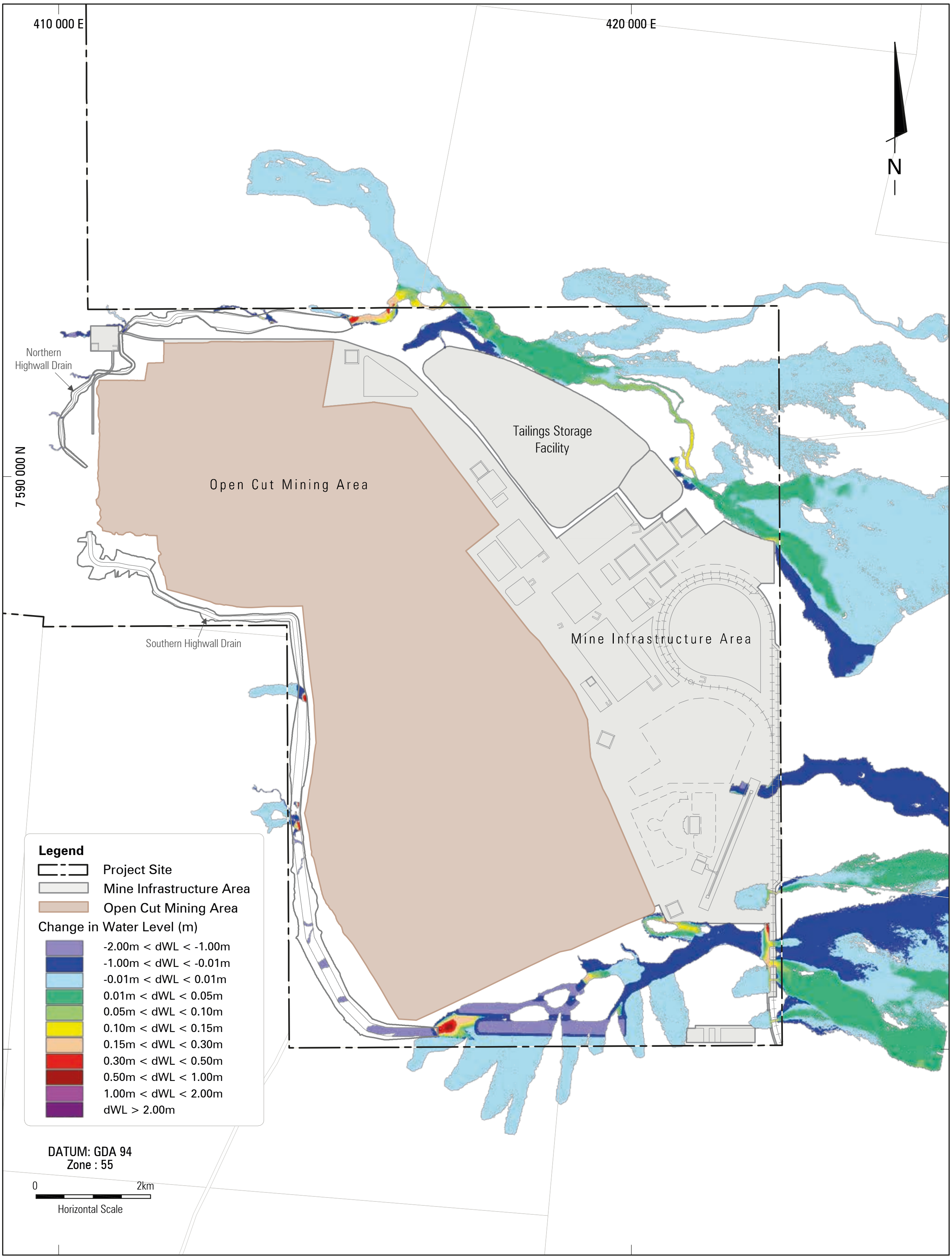
Conceptual Mine Water Management System

FIGURE 13-9



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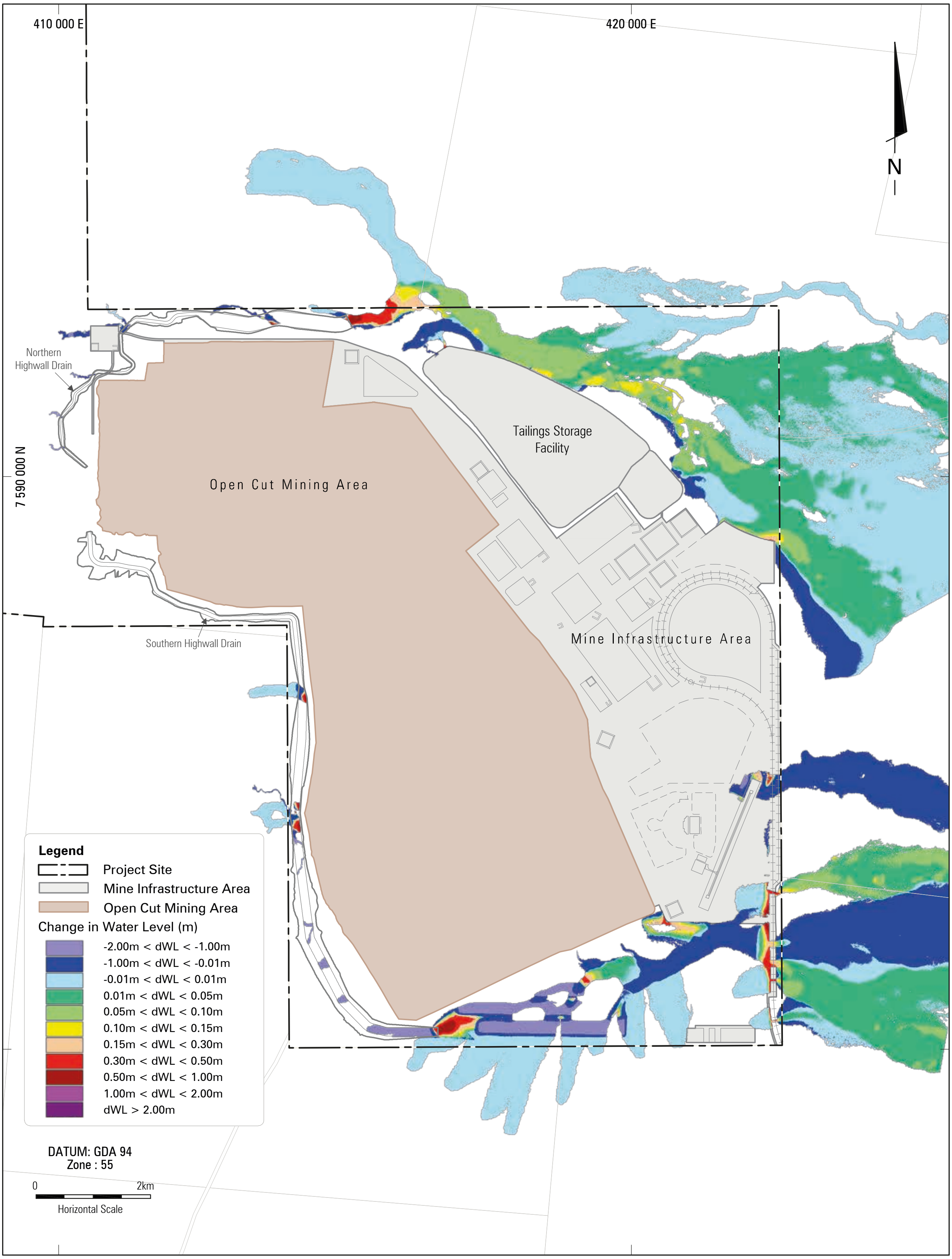
Predicted Flood Afflux for 1 in 2 AEP Flood Event

FIGURE 13-10



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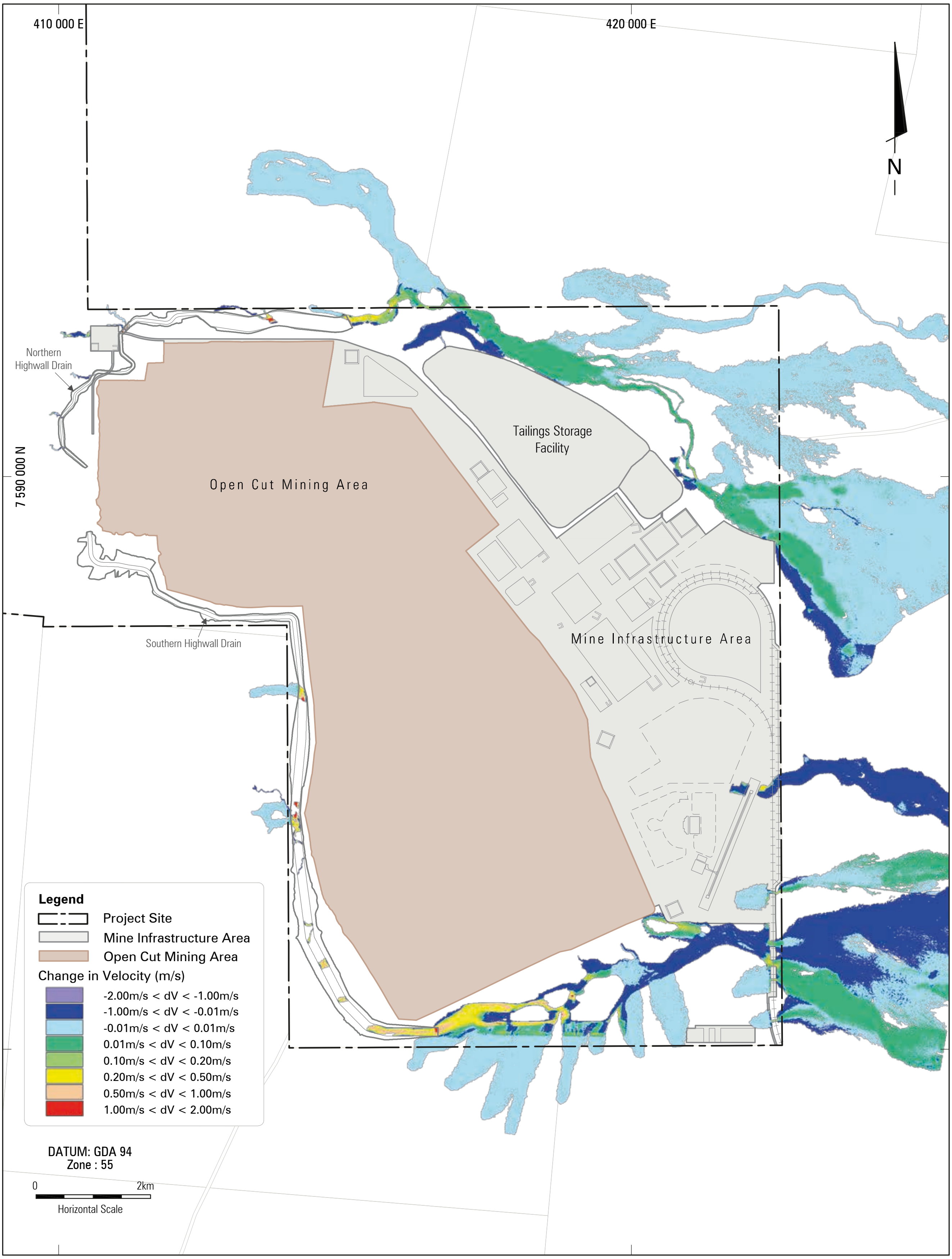
Predicted Flood Afflux for 1 in 50 AEP Flood Event

FIGURE 13-11

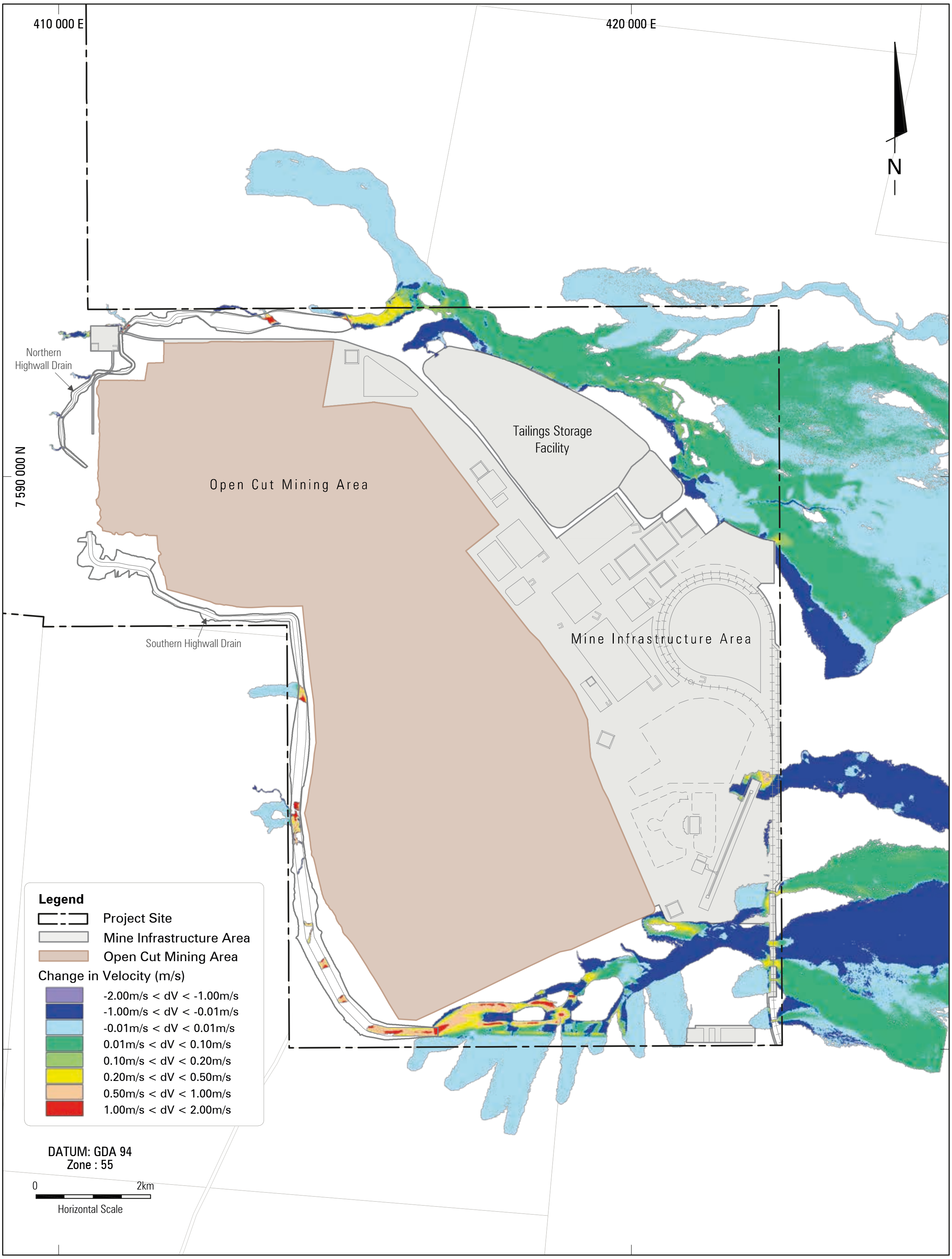


PROJECT CHINA STONE

MACMINES AUSTASIA | Hansen Bailey ENVIRONMENTAL CONSULTANTS

Predicted Velocity Change for 1 in 2 AEP Flood Event

FIGURE 13-12



PROJECT CHINA STONE

MACMINES AUSTASIA | Hansen Bailey ENVIRONMENTAL CONSULTANTS

Predicted Velocity Change for 1 in 50 AEP Flood Event

FIGURE 13-13

ATTACHMENTS

ATTACHMENT 13-1

Summary of Baseline Surface Water Quality

Table 1 Summary of Baseline Surface Water Quality Guideline Values

PARAMETER	WATER QUALITY GUIDELINE VALUES		
	Aquatic Environment[1]	Agriculture (Stock Watering)[2]	Agriculture (Irrigation)[3]
Ammonia N	0.01	N/A	N/A
Nitrite	N/A	30	N/A
Nitrate as NO_3	N/A	400	N/A
Total Nitrogen	0.25	N/A	N/A
Oxidised N	0.015	N/A	N/A
Total Phosphorus	0.03	N/A	N/A
Turbidity (NTU)	25	N/A	N/A
Suspended Solids	N/A	N/A	N/A
EC (µS/cm)	168 [7]	7,463 [4]	1,700 [5]
Total Dissolved Solids	113 [4]	5,000	N/A
Sulphate	N/A	1,000	N/A
Dissolved Oxygen (%)	90-110	N/A	N/A
pH	6.0-7.5	N/A	N/A
Alkalinity	N/A	N/A	N/A
Sodium	N/A	N/A	N/A
Calcium	N/A	1,000	N/A
Magnesium	N/A	N/A	N/A
Potassium	N/A	N/A	N/A
Chloride	N/A	N/A	175 [6]
Fluoride	N/A	2	2
Total Petroleum Hydrocarbons C_6-C_9	0.02 [8]	N/A	N/A
Total Petroleum Hydrocarbons C_{10}-C_{36}	0.1 [8]	N/A	N/A
Aluminium	0.055	5	20
Arsenic	0.013	0.5-5	2
Boron	0.37	5	N/A
Cadmium	0.2	N/A	N/A
Chromium	0.001	1	1
Cobalt	0.014	1	0.1

PARAMETER	WATER QUALITY GUIDELINE VALUES		
	Aquatic Environment[1]	Agriculture (Stock Watering)[2]	Agriculture (Irrigation)[3]
Copper	0.0014	1 (cattle)	5
Iron	0.3 [8]	N/A	10
Lead	0.0034	0.1	5
Mercury	0.0002 [8]	0.002	0.002
Manganese	1.9	N/A	10
Molybdenum	N/A	0.15	0.05
Nickel	0.011	1	2
Selenium	0.005 [8]	0.02	0.05
Silver	0.001 [8]	N/A	N/A
Uranium	0.001 [8]	0.2	0.1
Vanadium	N/A	N/A	0.5
Zinc	0.008	20	5

1 Derived from the Queensland Water Quality Guideline – Regional guideline values for physico-chemical indicators (slightly to moderately disturbed waters) and guidelines for aquatic ecosystem protection (slightly to moderately disturbed) as per ANZECC (2000), unless otherwise indicated

2 Guidelines for livestock drinking water (beef cattle)

3 Guidelines for agricultural irrigation based upon short term trigger values, as per ANZECC (2000) Table 4.2.10

4 Value calculated using 0.67 EC-TDS conversion factor, as per ANZECC (2000)

5 Guidelines for tolerance of field crops to salinity in irrigation water, as per ANZECC (2000) Table 4.2.5

6 Guidelines for chloride concentrations in field crops, as per ANZECC (2000) Table 4.2.6

7 Derived from the Queensland Water Quality Guideline – Table G4

8 Derived from Table F3 of the EHP model EA discharge conditions for mine-affected water

N/A Not Applicable

All concentrations in mg/L unless otherwise stated

Guideline values derived for Chromium, Copper, Lead, Nickel and Zinc unchanged by due to soft waters (median water hardness of 42 mg/L at Monitoring Location 3 derived from 89 measurements).

Table 2 Summary of Baseline Surface Water Quality Data – Monitoring Location 1

PARAMETER	WATER QUALITY GUIDELINE VALUES[3]	MONITORING LOCATION 1 – NORTH CREEK [2]	
		Number of Samples [1]	Median
Ammonia N	0.01	≥ 5	N/A
Nitrite	30	≥ 5	N/A
Nitrate as NO_3	400	≥ 5	N/A
Total Nitrogen	0.25	≥ 5	1,020
Oxidised N	0.015	≥ 5	N/A
Total Phosphorus	0.03	≥ 5	0.08
Turbidity (NTU)	25	≥ 5	25.3
Suspended Solids	N/A	≥ 5	N/A
EC (µS/cm)	168	≥ 5	567
Total Dissolved Solids	113	≥ 5	N/A
Sulphate	1,000	≥ 5	N/A
Dissolved Oxygen (%)	90-110	≥ 5	N/A
pH	6.0-7.5	≥ 5	**8.45**
Alkalinity	N/A	≥ 5	N/A
Sodium	N/A	≥ 5	N/A
Calcium	1,000	≥ 5	N/A
Magnesium	N/A	≥ 5	N/A
Potassium	N/A	≥ 5	N/A
Chloride	175	≥ 5	N/A
Fluoride	2	≥ 5	N/A
Total Petroleum Hydrocarbons C_6-C_9	0.02	≥ 5	<LoR
Total Petroleum Hydrocarbons C_{10}-C_{36}	0.1	≥ 5	<LoR
Aluminium	0.055	≥ 5	0.005 [4]
Arsenic	0.013	≥ 5	0.002 [4]
Boron	0.37	≥ 5	0.15 [4]
Cadmium	0.2	≥ 5	N/A
Chromium	0.001	≥ 5	< LoR [4]
Cobalt	0.014	≥ 5	< LoR [4]
Copper	0.0014	≥ 5	0.001 [4]
Iron	0.3	≥ 5	0.025 [4]

PARAMETER	WATER QUALITY GUIDELINE VALUES[3]	MONITORING LOCATION 1 – NORTH CREEK [2]	
		Number of Samples [1]	Median
Lead	0.0034	≥ 5	< LoR [4]
Mercury	0.0002	≥ 5	N/A [4]
Manganese	1.9	≥ 5	0.06 [4]
Molybdenum	0.05	≥ 5	N/A
Nickel	0.011	≥ 5	0.002 [4]
Selenium	0.005	≥ 5	N/A
Silver	0.001	≥ 5	N/A
Uranium	0.001	≥ 5	N/A
Vanadium	0.5	≥ 5	N/A
Zinc	0.008	≥ 5	< LoR [4]

1 Summary based upon minimum size sampling events conducted between October 2013 and April 2014

2 Limited range of statistics available based upon GHD 2013, therefore unable to do statistical analysis including percentiles

3 Derived from most conservative of the values presented in Table 1

4 Combined average metal and metalloid concentrations for Monitoring Locations 1 and 2 presented, as per Table 29 of GHD (2013)

Exceedances of guideline values shown in bold

All concentrations in mg/L unless otherwise stated

N/A Not Applicable

LoR Limit of Reporting

Table 3 Summary of Baseline Surface Water Quality Data – Monitoring Location 2

PARAMETER	WATER QUALITY GUIDELINE VALUES[3]	MONITORING LOCATION 2 – BELYANDO RIVER UPSTREAM [2]	
		Number of Samples [1]	Median
Ammonia N	0.01	≥ 5	N/A
Nitrite	30	≥ 5	N/A
Nitrate as NO_3	400	≥ 5	N/A
Total Nitrogen	0.25	≥ 5	**350**
Oxidised N	0.015	≥ 5	N/A
Total Phosphorus	0.03	≥ 5	**0.10**
Turbidity (NTU)	25	≥ 5	**37.8**
Suspended Solids	N/A	≥ 5	N/A
EC (µS/cm)	168	≥ 5	**979**
Total Dissolved Solids	113	≥ 5	N/A
Sulphate	1,000	≥ 5	N/A
Dissolved Oxygen (%)	90-110	≥ 5	N/A
pH	6.0-7.5	≥ 5	**8.11**
Alkalinity	N/A	≥ 5	N/A
Sodium	N/A	≥ 5	N/A
Calcium	1,000	≥ 5	N/A
Magnesium	N/A	≥ 5	N/A
Potassium	N/A	≥ 5	N/A
Chloride	175	≥ 5	N/A
Fluoride	2	≥ 5	N/A
Total Petroleum Hydrocarbons C_6-C_9	0.02	≥ 5	N/A
Total Petroleum Hydrocarbons C_{10}-C_{36}	0.1	≥ 5	N/A
Aluminium	0.055	≥ 5	0.005 [4]
Arsenic	0.013	≥ 5	0.002 [4]
Boron	0.37	≥ 5	0.15 [4]
Cadmium	0.2	≥ 5	N/A
Chromium	0.001	≥ 5	< LoR [4]
Cobalt	0.014	≥ 5	< LoR [4]
Copper	0.0014	≥ 5	0.001 [4]
Iron	0.3	≥ 5	0.025 [4]

PARAMETER	WATER QUALITY GUIDELINE VALUES[3]	MONITORING LOCATION 2 – BELYANDO RIVER UPSTREAM [2]	
		Number of Samples [1]	Median
Lead	0.0034	≥ 5	< LoR [4]
Mercury	0.0002	≥ 5	N/A
Manganese	1.9	≥ 5	0.06 [4]
Molybdenum	0.05	≥ 5	N/A
Nickel	0.011	≥ 5	0.002 [4]
Selenium	0.005	≥ 5	N/A
Silver	0.001	≥ 5	N/A
Uranium	0.001	≥ 5	N/A
Vanadium	0.5	≥ 5	N/A
Zinc	0.008	≥ 5	< LoR [4]

1 Summary based upon minimum size sampling events conducted between October 2013 and April 2014

2 Limited range of statistics available based upon GHD 2013, therefore unable to do statistical analysis including percentiles

3 Derived from most conservative of the values presented in Table 1

4 Combined average metal and metalloid concentrations for Monitoring Locations 1 and 2 presented, as per Table 29 of GHD (2013)

Exceedances of guideline values shown in bold

All concentrations in mg/L unless otherwise stated

N/A Not Applicable

LoR Limit of Reporting

Table 4 Summary of Baseline Surface Water Quality Data – Monitoring Location 3

PARAMETER	WATER QUALITY GUIDELINE VALUES[1]	MONITORING LOCATION 3 – BELYANDO RIVER DOWNSTREAM				
		Number of Samples	20th Percentile	Median	75th Percentile	80th Percentile
Ammonia N	0.01	9	0.008	**0.013**	**0.023**	**0.026**
Nitrite	30	-	N/A	N/A	N/A	N/A
Nitrate as NO_3	400	82	0.5	0.9	1.3	1.4
Total Nitrogen	0.25	45	**0.7**	**0.88**	**1.1**	**1.2**
Oxidised N	0.015	9	**0.02**	**0.08**	**0.13**	**0.15**
Total Phosphorus	0.03	53	**0.13**	**0.19**	**0.30**	**0.32**
Turbidity (NTU)	25	87	**100**	**158**	**318**	**476**
Suspended Solids	N/A	89	40	103	287	330
EC (µS/cm)	168	90	105	143	**183**	**193**
Total Dissolved Solids	113	90	76	101	**120**	**128**
Sulphate	1,000	83	1.9	2.9	4.2	4.8
Dissolved Oxygen (%)	90-110	55	**61**	**72**	91	94
pH	6.0-7.5	90	7.0	7.4	**7.7**	**7.7**
Alkalinity	N/A	90	36	51	64	70
Sodium	N/A	90	8	11	15	17
Calcium	1,000	90	7	10	13	13
Magnesium	N/A	90	2.8	3.8	4.8	5.0
Potassium	N/A	89	4.7	6.0	6.9	7.1
Chloride	175	90	6.2	9.7	15.8	17.9
Fluoride	2	87	0.08	0.11	0.19	0.20
Total Petroleum Hydrocarbons C_6-C_9	0.02	-	N/A	N/A	N/A	N/A
Total Petroleum Hydrocarbons C_{10}-C_{36}	0.1	-	N/A	N/A	N/A	N/A
Aluminium	0.055	62	0.05	**0.20**	**1.20**	**1.68**
Arsenic	0.013	-	N/A	N/A	N/A	N/A
Boron	0.37	83	0.03	0.05	0.08	0.09
Cadmium	0.2	-	N/A	N/A	N/A	N/A
Chromium	0.001	-	N/A	N/A	N/A	N/A
Cobalt	0.014	-	N/A	N/A	N/A	N/A

PARAMETER	WATER QUALITY GUIDELINE VALUES[1]	MONITORING LOCATION 3 – BELYANDO RIVER DOWNSTREAM				
		Number of Samples	20th Percentile	Median	75th Percentile	80th Percentile
Copper	0.0014	63	**0.01**	**0.03**	**0.03**	**0.03**
Iron	0.3	82	0.04	**0.58**	**1.66**	**2.06**
Lead	0.0034	-	N/A	N/A	N/A	N/A
Mercury	0.0002	-	N/A	N/A	N/A	N/A
Manganese	1.9	70	0	0.01	0.02	0.02
Molybdenum	0.05	-	N/A	N/A	N/A	N/A
Nickel	0.011	-	N/A	N/A	N/A	N/A
Selenium	0.005	-	N/A	N/A	N/A	N/A
Silver	0.001	-	N/A	N/A	N/A	N/A
Uranium	0.001	-	N/A	N/A	N/A	N/A
Vanadium	0.5	-	N/A	N/A	N/A	N/A
Zinc	0.008	62	**0.01**	**0.01**	**0.04**	**0.05**

1 Derived from most conservative of the values presented in Table 1

Exceedances of guideline values shown in bold

All concentrations in mg/L unless otherwise stated

N/A Not Applicable

Table 5 Summary of Baseline Surface Water Quality Data – Monitoring Location 4

PARAMETER	WATER QUALITY GUIDELINE VALUES[1]	MONITORING LOCATION 4 – SUTTOR RIVER				
		Number of Samples	20th Percentile	Median	75th Percentile	80th Percentile
Ammonia N	0.01	8	**0.015**	**0.017**	**0.021**	**0.023**
Nitrite	30	-	N/A	N/A	N/A	N/A
Nitrate as NO_3	400	71	0.5	1.0	1.4	1.5
Total Nitrogen	0.25	36	**0.69**	**0.89**	**1.08**	**1.11**
Oxidised N	0.015	8	**0.026**	**0.089**	**0.128**	**0.138**
Total Phosphorus	0.03	43	**0.10**	**0.19**	**0.25**	**0.30**
Turbidity (NTU)	25	72	**100**	**149**	**362**	**397**
Suspended Solids	N/A	81	40	102	187	247
EC (µS/cm)	168	86	115	147	**184**	**201**
Total Dissolved Solids	113	85	79	100	**126**	**130**
Sulphate	1,000	73	2.3	3.4	5.0	5.8
Dissolved Oxygen (%)	90-110	1	N/A	64	N/A	N/A
pH	6.0-7.5	86	7.1	7.4	**7.6**	**7.6**
Alkalinity	N/A	86	38	50	62	66
Sodium	N/A	86	8.8	12.9	17.8	20
Calcium	1,000	86	7	9	12	13
Magnesium	N/A	86	2.9	4.0	5.0	5.2
Potassium	N/A	81	4.2	5.0	5.8	6.1
Chloride	175	86	8	12	20	22
Fluoride	2	79	0.10	0.10	0.15	0.16
Total Petroleum Hydrocarbons C_6-C_9	0.02	-	N/A	N/A	N/A	N/A
Total Petroleum Hydrocarbons C_{10}-C_{36}	0.1	-	N/A	N/A	N/A	N/A
Aluminium	0.055	49	0.03	**0.18**	**0.51**	**0.62**
Arsenic	0.013	-	N/A	N/A	N/A	N/A
Boron	0.37	68	0.03	0.06	0.08	0.09
Cadmium	0.2	-	N/A	N/A	N/A	N/A
Chromium	0.001	-	N/A	N/A	N/A	N/A
Cobalt	0.014	-	N/A	N/A	N/A	N/A
Copper	0.0014	48	**0.01**	**0.03**	**0.03**	**0.03**

PARAMETER	WATER QUALITY GUIDELINE VALUES[1]	MONITORING LOCATION 4 – SUTTOR RIVER				
		Number of Samples	20th Percentile	Median	75th Percentile	80th Percentile
Iron	0.3	75	0.05	**0.38**	**2.05**	**2.34**
Lead	0.0034	-	N/A	N/A	N/A	N/A
Mercury	0.0002	-	N/A	N/A	N/A	N/A
Manganese	1.9	61	0.00	0.01	0.01	0.02
Molybdenum	0.05	-	N/A	N/A	N/A	N/A
Nickel	0.011	-	N/A	N/A	N/A	N/A
Selenium	0.005	-	N/A	N/A	N/A	N/A
Silver	0.001	-	N/A	N/A	N/A	N/A
Uranium	0.001	-	N/A	N/A	N/A	N/A
Vanadium	0.5	-	N/A	N/A	N/A	N/A
Zinc	0.008	50	**0.01**	**0.01**	**0.03**	**0.03**

1 Derived from most conservative of the values presented in Table 1

Exceedances of guideline values shown in bold

All concentrations in mg/L unless otherwise stated

N/A Not Applicable

Table 6 Summary of Baseline Surface Water Quality Data – Monitoring Location 5

PARAMETER	WATER QUALITY GUIDELINE VALUES[1]	MONITORING LOCATION 5 – BURDEKIN FALLS DAM				
		Number of Samples	20th Percentile	Median	75th Percentile	80th Percentile
Ammonia N	0.01	7	0.007	0.008	0.009	0.009
Nitrite	30	-	N/A	N/A	N/A	N/A
Nitrate as NO_3	400	69	0.5	0.5	0.9	0.9
Total Nitrogen	0.25	45	**0.34**	**0.42**	**0.52**	**0.54**
Oxidised N	0.015	7	**0.05**	**0.1**	**0.13**	**0.14**
Total Phosphorus	0.03	50	**0.032**	**0.054**	**0.073**	**0.074**
Turbidity (NTU)	25	71	15	**80**	**124**	**145**
Suspended Solids	N/A	77	9	16	40	53
EC (µS/cm)	168	77	128	153	**202**	**233**
Total Dissolved Solids	113	77	83	95	**121**	**139**
Sulphate	1,000	67	1.6	2.0	2.4	2.6
Dissolved Oxygen (%)	90-110	52	94	105	**113**	**116**
pH	6.0-7.5	77	**7.6**	**7.9**	**8.0**	**8.0**
Alkalinity	N/A	77	49	59	80	88
Sodium	N/A	77	9.2	11.0	16.0	17.4
Calcium	1,000	77	8.7	10.1	13.2	14.0
Magnesium	N/A	77	4.2	5.1	7.9	8.4
Potassium	N/A	77	3.0	3.3	3.7	3.8
Chloride	175	77	8.1	10.6	15.0	16.8
Fluoride	2	75	0.08	0.10	0.11	0.11
Total Petroleum Hydrocarbons C_6-C_9	0.02	-	N/A	N/A	N/A	N/A
Total Petroleum Hydrocarbons C_{10}-C_{36}	0.1	-	N/A	N/A	N/A	N/A
Aluminium	0.055	58	0.024	**0.060**	**0.308**	**0.352**
Arsenic	0.013	-	N/A	N/A	N/A	N/A
Boron	0.37	69	0.01	0.03	0.04	0.04
Cadmium	0.2	-	N/A	N/A	N/A	N/A
Chromium	0.001	-	N/A	N/A	N/A	N/A
Cobalt	0.014	-	N/A	N/A	N/A	N/A
Copper	0.0014	60	**0.01**	**0.03**	**0.03**	**0.03**

PARAMETER	WATER QUALITY GUIDELINE VALUES[1]	MONITORING LOCATION 5 – BURDEKIN FALLS DAM				
		Number of Samples	20th Percentile	Median	75th Percentile	80th Percentile
Iron	0.3	68	0.01	0.06	0.25	0.27
Lead	0.0034	-	N/A	N/A	N/A	N/A
Mercury	0.0002	-	N/A	N/A	N/A	N/A
Manganese	1.9	58	0.00	0.01	0.01	0.01
Molybdenum	0.05	-	N/A	N/A	N/A	N/A
Nickel	0.011	-	N/A	N/A	N/A	N/A
Selenium	0.005	-	N/A	N/A	N/A	N/A
Silver	0.001	-	N/A	N/A	N/A	N/A
Uranium	0.001	-	N/A	N/A	N/A	N/A
Vanadium	0.5	-	N/A	N/A	N/A	N/A
Zinc	0.008	58	0.004	**0.010**	**0.020**	**0.020**

1 Derived from most conservative of the values presented in Table 1

Exceedances of guideline values shown in bold

All concentrations in mg/L unless otherwise stated

N/A Not Applicable